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A NEW SYSTEM OF HOUSE AND UNDERGROUND WIRING.

ONCE more the ingenuity of American workers has produced a new conduit system, which in this particular case is to be applied to both indoor and underground work. It is being introduced by the Interior Conduit and Insulation Company, and the March number of the *Journal* of the Franklin Institute contains, first, a report by the Franklin Institute Committee on Science and the Arts, on the system as applied to house wiring, and, secondly, a paper read before the Institute by Mr. E. H. Johnson, which deals with the same system, but with more especial reference to its application to underground work.

As applied to house wiring, the committee's report describes it as a system of continuous tubes (made of paper soaked in a bath of bituminous compounds at a temperature of 460° Fah.) which are placed throughout the building, and into which the wires are afterwards drawn. These tubes are made in sizes from one-quarter inch to one and a-half inches in internal diameter, and may be run under the plaster of the walls, or may be attached to the wall by brass clips, in which case they are finished externally in such a manner as to accord with the general decoration of the room. Separate lengths of tubing are joined by enclosing the two abutting ends in a sleeve, and at corners bends are inserted and joined to the tubes in a similar manner. At intervals junction boxes are inserted to facilitate the drawing in of wires, and to allow of the taking off of branches.

The committee report that the tubes are hard, strong and tough, that they are waterproof, and insulate the wires electrically from the material of the building, that they can be made fireproof by a coating of suitable paint, which protects them from ignition from the outside, and that they cannot be ignited from the inside by overheating of the wires, owing to the want of sufficient air to support combustion. For large mains each wire has a separate tube, but for smaller mains and branches the two wires are run in one tube, and in both cases the wire used has only a light textile insulation. The report further says: "The following experiments were shown to the committee:—A leak was forced between two wires, run, as is usual, on a wooden moulding, 2½ inches apart, the leak was made, moistening the moulding with a solution of soda. The leakage was too small to actuate the safety fuses, but was large enough to char and set fire to the wood. The wires were placed close together, as in the system of tubes, and the leak was produced as before. The leakage was so great that the safety fuses acted immediately, before any charring or ignition of the wood had time to take place. In another experiment a wire was secured to a piece of wood, and a continuation of the same wire was passed through the tubes; the whole wire was then overloaded, so as to cause it to heat. The wood was set on fire, but the tube was not hot enough to do any harm, although the insulation around the wire itself had been completely consumed by the heat. Other experiments were made showing that a short circuit in a tube would not start a fire, while a similar short circuit in the open air or moulding is very apt to be a source of fire."

Although it is difficult to come to definite conclusions on a matter of this kind without first seeing the system in use, a few comments on the experiments quoted above, and on the general idea of the system may not be out of place. The first experiment does not appear a very convincing one, as it merely shows that if two badly insulated wires are put close together either surrounded by wood or by this new tube, a short circuit is formed between the wires when they are moistened, which blows the fuses before the surface of the wood or tube has time to get charred. In the second experiment, it appears that the wire was secured on the surface of the wood, and was not shut in as is the usual practice here with wires run in wood casings. Indeed on this point there is no reason why there should be a smaller supply of air to support combustion in the tube than in the ordinary wood casing, in which the wire generally fits as tight as it could be made to fit in a tube into which it has to be drawn. With regard to the system generally, any convenient arrangement of conduits which facilitates drawing the wires in and out is a move in the right direction; more especially now that the plan of running a large number of very small current circuits

direct from a distributing board is being so much more used than formerly; and it would be an excellent thing if the present clumsy system of wood casings could be replaced by something better. The use of wood casings, which is so strongly insisted on by most authorities, adds considerably to the cost where a sightly appearance is required without giving many corresponding advantages, and its obtrusiveness is a direct incentive to the use of the system of hidden wiring, than which nothing can be more inconvenient should a fault occur. Although affording a fair mechanical protection, wood casing is practically useless in all other respects; as although it may be dry when put up, it generally manages to become damp enough to allow of a current passing should there be a leak between the wires, and if exposed to the air, it is as inflammable as any casing that could be devised. It may not be orthodox to say anything against the use of wood casing, but really the question is worth considering; and it appears as if everyone has been accustomed for so long to using it, that they have not troubled to think out the *pros* and *cons* for themselves, and to consider how many cases there are in which it would be permissible, and not only that, but also safer to run the wires without casing of any kind, so that they are in full view, and easily accessible. Again, when wiring must be hidden, as, for instance, when it is run between floors and ceilings, or beneath the surface of the wall, the advantages of a drawing-in system are considerable; and it is a matter of surprise that iron pipes, which in many cases do not cost much more than wood casing, are not more frequently used. Should this bitumenised paper tube prove reliable and fairly cheap, there should be a good field for its use for internal wiring; but in any case, no matter of what material the conduit is made, the proposal to use a wire lightly insulated with fibrous material appears to be simply asking for short circuits, so that one may show the advantages of a drawing-in system for replacing a faulty wire. In this connection it is impossible to pass without comment a statement made by Mr. Johnson, in which he describes the paper tube system as "a well worked out scheme of supplanting or supplementing the former practice of attaching the insulation to the wire itself by a system of insulated raceways, into which to draw the wires, and which supplies in itself a degree of high and durable insulation not attainable by the old methods." Surely Mr. Johnson must, on this occasion, have been carried away by his enthusiasm for the system he was describing, or else he must have been very little acquainted with the quality of many of the insulated conductors in use at the present day, and have based his comparison on the results that used to be obtained with wire such as that which earned for itself the name of "underwriters wire."

This same system of paper tubes, as modified for underground work, may be described as follows:—A series of tubes of any given number and diameters is formed into a bundle, and pushed into a cast iron pipe, and the whole is then immersed in a bath of compound in such a manner that all the spaces between the outsides of the tubes are filled up with compound, leaving therefore a number of separate smooth ducts within the cast iron pipe. The pipes are made in 10-foot lengths, and when they are being laid, the ducts in two lengths of pipe are joined together by means of similar tubes of the same length, and of an external diameter slightly less than the internal diameter of the ducts, these tubes being coated with an insulating compound, and telescoped into the ducts in such a manner that the abutting ends of the inner tubes are midway between the ends of the outer tube. With this method of joining it is claimed that the duct formed of the two series of complete tubes cemented together is as perfect in its continuity as if it had been made in the factory in one unbroken length. The cast iron containing pipes are united by a special sleeve filled with insulating compound, and sealed by the insertion of a lead gasket between the sleeve and the ends of the pipes. The manholes are of cemented brick, the method of preventing moisture from entering the ducts being described as follows:—"The section of the general containing pipe entering the man-hole is expanded in a funnel form to about double its normal diameter for the purpose of separating, and therefore providing a greater space around the duct ends for more perfect manipulation. The end of this funnel is provided with an iron head, on the face of which are short pipe projections corresponding to the number of ducts, and into each of which a duct end terminates. These iron nipples are threaded on the outside for the reception of a metallic cap or coupling. When the conductor has been drawn into the duct a section of lead pipe with an insulated lining is pushed over the end of the conductors, and a short distance into the duct itself; a coupling is then screwed on to the cap and over the lead-encased conductor, and so firmly screwed home as practically to consolidate the lead sheathing and iron nipples, and thus hermetically seal the end of the duct. The corresponding end of the conductor on the opposite side of the man-hole having been treated in the same way, it now only remains to join the broken sections of the conductors and their lead sheathing, hang the completed conductor upon its proper rack at the side of the man-hole, and proceed to treat each of the other conductors in a like manner."

Mr. Johnson claims that this conduit provides in itself an insulation ample for all purposes, so that there is no need to use the general costly and cumbersome insulations on the wire itself, and speaks of the chief defect in previous conduits as the neglect of the problem of insulation, an opinion which is somewhat at variance with that held over here as to American systems, which rather attributes the difficulties that have been met with to the fact that the conduit has too often been depended on for insulation, and, therefore, that an inferior cable has been used.

It is probable that this system has not yet been fully tried in practical work, and that when it reaches that stage some of the details will most likely present greater difficulties than the inventors anticipate; as for instance, the tedious nature of the operation of telescoping the pipes, and the difficulties that will occur when there are continual slight deviations from a straight run. And when the continuous tube is made, it cannot claim any great advantage over a Callender-Webber casing protected by an inverted iron trough, and the use of a practically bare conductor in this latter casing would hardly be recommended even by its most ardent advocates. The difficulties of excluding moisture at the manholes appear to be underrated, when it is considered that there will be four joints, two of them screwed and two soldered, in each length of lead pipe which connects the ends of corresponding ducts; that the taking off of branches entails further cutting and jointing of the lead pipes, and that since the wires are accessible only at manholes, each branching-off place neces-

sitates the building of a manhole, and entails the fitting of all these lead sleeves with their chances of leakage. Such a system must appear risky to any one who has had experience of the difficulties of making and keeping tight a large number of pipe joints underground, and is not very likely to make a favourable impression on the majority of electrical engineers, who will probably require much more convincing proofs than are given in the paper, before they endorse the concluding remarks of the author, which are:—"We feel free to express our conviction that in point of first cost, durability, flexibility, insulation, cleanliness, economy of maintenance, economy of space, and general adaptability, no other combination of underground conduit and conductors can even approximately equal this system."

COAST COMMUNICATION.

It is with considerable pleasure we notice in the columns of our contemporary, the *Standard*, the letter of Mr. T. G. Wren, and the leading article in the same journal founded thereon. Mr. T. G. Wren advocates with a powerful pen the propriety—nay, the very need—of establishing a string of communications around the entire coastline of the country, connecting therewith lighthouses and lightships, and, at certain points, bringing the same into connection with the general telegraphic system of the country. With considerable force Mr. Wren shows how such communication with many of our lighthouses might have been of service in saving life—in making known to the lifeboat service the presence of disabled and wrecked vessels, hidden from the view of those on shore by fog, or other causes; and no less clearly does he argue the advantages of a coast communication for other purposes.

Thoroughly as we endorse all Mr. Wren says, cordially as we wish his advocacy success, and spurred on as we hope it may be by the able and powerful advocacy of our contemporary, we fear our authorities will remain, as hitherto, blankly indifferent to the need until some dire calamity arises, when probably it will be too late to do anything. Readers of these pages will be aware how we have from time to time advocated the need of communication around our coasts, not only for coastguard or war defences, but for other and equally serviceable objects. War, we all trust, is a far off contingency; but storms and shipwrecks will ever unfortunately arise. To render aid in such cases is to save life. To render it promptly is to save more life. Nor would the communication be useless at other times. In many parts of the coast, to our fishing industry it would be a boon, carrying with it some degree of wealth. All this we have from time to time pointed out. We are glad to see the subject taken up by others. We scarcely think it probable the scheme, as promulgated by Mr. Wren, likely to receive favourable consideration in its entirety, but we see no reason why what has so frequently been advocated by ourselves as well as others, viz., the provision of a telephonic coast-line—say, from the Mersey to the Thames—should not be countenanced. Such a line, connected at points with the inland network of telegraphs, could not fail to be of the greatest service. The section of coast named is probably the most important which could be selected; the cost would not be a very outrageous one. The service it would render in respect of shipping, fishing, and in many other ways would, we feel, speedily lead to its extension to other parts. Those who have read Mr. Wren's letter will have had brought before them in a very forcible and able manner many instances in which such a communication would in all probability have saved life; whether it would effect economy in coastguard service is also a question open to consideration. With a properly constructed and devised system it should be possible for the coastguardsman when on his beat to obtain communication with, and aid if required, from his headquarters. As a preventative to contraband trading, it would prove equally useful, for few would venture to land contraband goods at any point having such ready means of call at hand.

Communication with lighthouses has been so frequently advocated that it would appear unnecessary to again go over the beaten track. Everybody must admit its desirability. In many instances there may be difficulty in maintaining the communication. Lighthouses as a rule are not to be found where rocks are few and the waves gentle, but there are exceptions. Why not try one or more. Why not try some of the exceptions first? We do not think the task is one which would be shirked by our engineers. They would not desert it, and, in the end, we have little doubt would overcome the most difficult of the connections required to be made.

With lightships there would, of course, be more difficulty, owing to the instability of the structure to which the cable would have to be connected; but connections with lightships might well be deferred till connection with lighthouses had been secured. We believe that if the Government were to take in hand a section of the coast, and the lighthouses embraced within it, they would confer upon our shipping and fishing industry a well merited boon, and reap the gratitude of the entire country. We are glad to see Mr. Wren's advocacy, and the support it has received from our contemporary; and we heartily wish they may receive that consideration, and be attended with that success which the subject deserves. A letter on the same subject in our correspondence columns reached us after the above lines were in type; we strongly recommend a careful perusal of this communication, which, while agreeing in the main with what we have said, goes still further into the technicalities of the subject.

MONOPOLIES AND MESSENGERS.

For a week or two past there has been considerable commotion in the press and some "heckling" in Parliament on the subject of the suppression of the Boy Messengers and the District Messenger Companies, in so far as their service interferes with the monopoly of the Post Office. We were gravely told in one quarter that the Government was imperilled, and in another that the Postmaster-General was to be sacrificed. The anxiety of the public to have messenger calls was such that any Postmaster-General who interfered with their supply must be at once relegated to some other post or turned out of the Government altogether. The incident will be made a strong argument for the head of the Post Office, being a permanent official. At present, the lot of a Postmaster-General is not altogether a happy one. Being a member of a party organisation there is always "Her

Majesty's Opposition" in Parliament and their adherents in the press ready to find fault with him. This condition of things is common to himself and his colleagues, but unlike the latter, his office is not particularly identified with questions of party policy, and whilst this in no way tends to reduce the fervour of the attack, it prevents his political friends or his party's press finding any need to defend him or to refrain from joining in an attack upon him. Thus does a Postmaster-General at times find himself with every man's hand against him. At such times one has an inclination to agree with the statement that in the absence of a consummately able Postmaster-General the next best thing is a pachydermatous Postmaster-General.

In reviewing the circumstances, it is found that in order to afford employment to a number of boys a messenger corps was formed. More recently a company was inaugurated for the purpose of supplying messengers, cabs, &c., on receipt of of a notification by means of a system of automatic telegraphs. The superiority of this method being apparent, the boy messenger organisation decided upon adopting it in conjunction with their existing system. Observing these inroads upon his territories, the Postmaster-General notified both companies that they must not infringe his monopoly. Opponents in prosperity, the competing companies take common cause in adversity, and with full appreciation of their opportunities furnish the press with their views of the matter, and the press ably seconds their efforts, points out the injustice of the Postmaster-General in stopping their business after their capital was invested, and so on.

That the Post Office holds a monopoly of the transmission of letters is well-known; that it holds a monopoly of the transmission of public telegrams is also well known. The system of messenger and other calls transmitted by electric signals from a subscriber's house by means of an automatic call box has been used in America for many years. It preceded the telephone and has grown with it. Such a system would certainly have been started here some years ago but for the generally recognised position of the Post Office and the probable inability of the promoters to receive the necessary permission. The existing companies appear to have carried on their operations so far without regard to the Post Office permission. This may have been due to a want of appreciation of the exclusive rights which the Post Office claimed or to a determination to proceed in spite of them. To this the public are indebted for an opportunity of testing in actual work the benefit of the electric call and messenger system. The Post Office did not initate it, but the claims of the companies to favourable consideration for embarking capital in the business are subject to the rule that when a player forces his opponent's hand, he incurs a risk for which he should be prepared.

The Postmaster-General has received very general censure for interfering with the operations of the companies, but the Postmaster-General is at the head of a public department—a money-earning department. He is expected to guard the interests of his department, and it is his duty to prevent others from interfering with its sources of revenue. The public cannot have the benefits of Governmental monopoly and of free trade in the transmission of letters and telegrams as well. It has been urged that the interests of the public, the companies, and the Post Office would be met by giving licenses to the companies to carry on their businesses. This is a suggestion worthy of all consideration, but not to be decided off hand as the result of popular clamour.

Unfortunately, the Postmaster-General has himself contributed material for unfavourable criticism by not being content to do one thing at a time. His suppression of one service was accompanied by the notification of a prompt delivery service of his own, which his opponents say—and say truly—is no sufficient substitute for the one suppressed. This was followed by another announcement of a call service in one district, the instruments to be used being telephones.

The latter announcement seems to us only to extend the area of the Postmaster-General's opponents. A telephone service is not the same thing as a call service. It is more expensive to instal and maintain and is less easy to work than a call-box service. Had the Postmaster-General been content to assert his rights first and decide on the methods to be adopted to supply the wants of the public afterwards, he would have been more likely to arrive at a correct solution of the delicate problems involved than by a simultaneous suppression of one and the creation of other systems. Hasty action is always liable to error, and this is more especially the case with public departments.

The success of the call system in the United States is well known. The companies introducing it here are not introducing any new invention. They are only "exploiting" a new field, which would certainly have been opened up before by others, except that they realised the responsibility and were not disposed to found a business and find themselves in the position of a purchaser of an estate with a flaw in the title deeds.

Nevertheless, the existing companies should receive reasonable consideration. If they were encouraged to proceed by implied promises or on the principle that silence gives consent, they should be permitted to continue on equitable terms of license or receive consideration for being arrested in their progress. But inconsiderate abuse of the Postmaster-General will not conduce to a settlement of the question in a manner which will be permanently satisfactory. "Now the question of monopoly was fought out some years ago when the Post Office took over the telegraphs from the old companies, and it was then thought that a monopoly was good, but that it was only good in the hands of the State. A private company, although it might be pressed, was not necessarily obliged to yield, but the State, represented by the Postmaster-General, was bound to give the greatest facilities to the public." These are not the words of an outsider, but of an able permanent official of the Post Office—the late Mr. Patey. Mr. Raikes may well weigh the last words, and remember that "the Postmaster-General is bound to give the greatest facilities to the public," and the public may well be content to impress that fact upon the Postmaster-General, and leave him to provide those facilities in the way which experience, and a due regard to the interests of his Department, may show to be the best.

Applied Electricity in Demerara.

GEORGETOWN, Demerara, had no sooner got its 200-wire telephone exchange than it began to sigh for more, and now the Government has determined upon increasing the number to 400, so popular has it become, with its appreciated continuous service and cheap rates of fifty shillings a year. The town of New Amsterdam, some seventy miles distant, is also to have its exchange. Contemporaneous with this work is that of the renewal or rather rebuilding of the telegraph

lines of the colony, for Mr. Vyle has persuaded the powers that be to let him replace the old badly jointed iron wires with No. 14 copper, and an entirely new equipment of insulators. The electric light has not only been talked about but is actually lighting some of the streets of Georgetown, under agreement with the Town Council. The popular wife of the Governor of British Guiana, the Viscountess Garmanston, inaugurated the opening of the electric light and power station, before a brilliant gathering, on the 17th of January, and already a large number of private houses have been lit. The hall of the Royal Agricultural and Commercial Society, was specially fitted up to illustrate a lecture delivered by Mr. Vyle, the government electrician, on the 26th of February last. The Thomson-Houston is the system employed, and both arc and incandescent lamps are used. The prettiest street, known as Main Street, with a deep water trench down the centre between two roads, having trees on either side of the water, looks quite fairy like, whilst the rays of the arc lamps in front of the club, cause the latter to be seen a long way off. Altogether Demerara is looking up in matters appertaining to applied electrical science.

English Submarine Cables

The *Electrical Engineer* devotes two columns to a criticism of our review of Mr. Lagarde's contributions to the *Annales Télégraphiques*, and concludes by expressing surprise that we should oppose ourselves to the progress of science. We have, also, our surprise: and the cause of it is, the *Electrical Engineer's* perversity in so misreading our article as to suppose that we would discourage "able and painstaking observers" from studying the chemistry of gutta-percha. We should naturally like to see not one man, but a hundred working at this subject; but the purport of our article was to suggest more modesty in the enunciation of laws upon insufficient knowledge. There is no greater enemy to any cause than the man who overstates it. We repeat our statement that the chemist is a very useful man; but we maintain our opinion that the chemist who after making a few crude experiments advocates that a chemical test should, *in the present state of our knowledge*, be inserted in specifications for core, does harm to his science. The chemistry of gutta is absolutely in its infancy, whereas, we have forty years of practical experience regarding its mechanical and electrical conditions. We therefore object altogether to a chemical test ranking in a specification *pari passu* with mechanical and electrical tests. The *Electrical Engineer* says: "As we before suggested, manufacturers may perhaps look at the matter from a different point of view, and they may very naturally object to such stipulations in their contracts as may entail greater vigilance and increased expense, together with a better knowledge of the material in course of manufacture." We have a higher opinion than our contemporary regarding the manufacturer. We believe him sufficiently intelligent to comprehend that a better knowledge of the material that he manufactures *must* be advantageous to himself; as to the "greater vigilance and increased expense," it is the *purchaser*, not the manufacturer, that pays for these. It would be unprofitable to wander with the *Electrical Engineer* into the two columns which precedes its conclusion. A single quotation from them will suffice to illustrate the value of the criticism. It states: "Surely our contemporary cannot be ignorant of the fact that all, or nearly all, submarine cable contracts offered in this country to general tender contain a clause stipulating, not only the minimum, but also the maximum dielectric resistance." We confess to what the *Electrical Engineer* calls ignorance, and we invite him to enlighten it by proving what he states to be a fact. Was there a maximum limit in the specification for the telephone cable that was laid the other day across the channel, and whenever this maximum is mentioned is it not mainly in postal telegraph specifications, and was it not initiated by the P.O. officials? The whole article, however, is so worthless that we should not have taken notice of it at all if it had not been put forward with the authority of a contemporary journal.

Comparative Cost of Electric and Horse Traction on Continental Tramways.

Mr. Hugo Köstler in a paper read before the Society of Austrian Engineers, which is partly reproduced in our contemporary, *Der Electro-Techniker*, gives some interesting statistics relating to several tramways in Austria and Germany. Special reference is made to the Buda-Pest electric tramway which has been in successful operation for about a year. The underground conduit system is here employed on three different lines with a total length of 16 kilometres. We have on previous occasions dwelt upon the general construction of this tramway which was equipped by Messrs. Siemens and Halske, and we repeat now a few of the main points in order to give this communication sufficient completeness. Following the best American practice the cars are built with special care and possess an elegant appearance which pleases the eye of that portion of the public which has hitherto looked down upon tramways in general. We know it from competent authorities that handsome cars have the effect of largely increasing the revenue of tramway companies, and this is a fact which is not sufficiently recognised in this country. After a considerable amount of hesitation the Buda-Pest Municipality gave permission for a maximum speed of 11 miles an hour through the city streets, and this was granted after it was shown that the electric cars could be brought to a standstill within 24 feet when running at full speed and on frozen rails. With reference to the actual cost of construction and equipment of Austrian lines it was shown that the horse tramways in Vienna have cost 41,000 florins per kilometre; the steam tramways in the same city, 70,000 florins; and the electric tramway in Budapest, 30,000 florins per kilometre, of which 14,000 florins was expended on the conduits. Most remarkable are the comparative figures showing the difference of cost between animal and electric traction. Thus at Frankfort the tramway worked with horses expends 5·64 pence per car kilometre, whereas the electric tramway covers this item with 2·88 pence. It is also interesting to note the growing popularity of the electric line at Budapest, which carried in April, 1890, 2,590 passengers per kilometre, whereas in December, of the same year, 3,621 persons were carried. The horse tramway of the same city, on the other hand, carried 2,730 and 2,267 passengers respectively during the corresponding months, which returns show a retrograde step. But the climax of all this most satisfactory state of affairs is reached when we compare the earning capacities of two tramways in the same city, both of which enjoy the same privileges. Thus the expenses of the electric tramway were only 45·4 per cent. of the gross income, whilst in the case of the tramways worked with horses, the ratio between expenditure and income was 71·8 per cent., which corresponds with most of the lines in England. The lecturer concludes that this result in the case of the electric line would have been still more satisfactory, but for the fact that the original method of gearing (steel cords) was defective, and involved a very heavy expenditure, in consequence of which chain gearing has since been substituted, but the cost of which was charged to maintenance. The electric traction expenses, nevertheless, were covered by 2·8 pence per car kilometre, and hopes are entertained that still further economy will be effected. We only trust that these figures which speak so eloquently in favour of electricity will be brought home to the responsible bodies in this country, who have in their power the means of completely re-organising our antiquated and inadequate methods of working tramways, but who still hold aloof.

AN EXPERIMENT WITH THE ELECTRIC ARC.*

BY WM. STANLEY, JUN.

PROF. THOMSON'S paper on arc lights calls to my mind an experiment in the laboratory some time ago with an alternate current arc, which presented a very beautiful illustration of the deflecting power of a strong magnetic field. Inside a

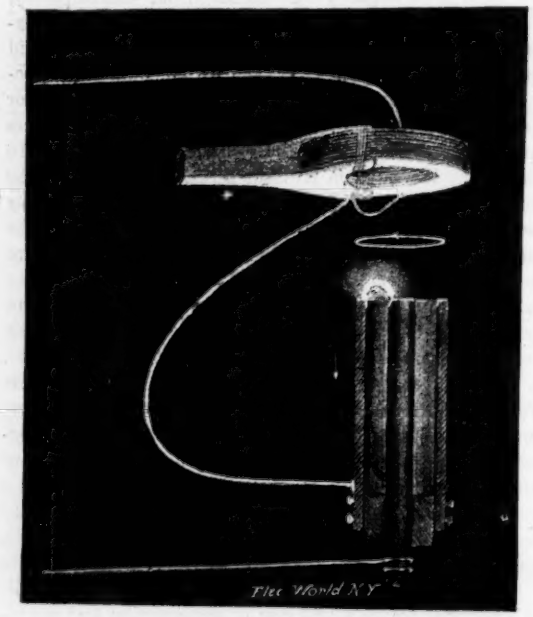

FIG. 1.—ROTATION OF THE ELECTRIC ARC.

hollow carbon tube about 2 inches in diameter was placed an ordinary seven-eighths inch carbon, separated from the tube by about one-quarter of an inch air space all around except where it was held in place by an insulating ring, as shown in fig. 1. A coil of wire connected in series with the carbons,

FIG. 2.—SIMULTANEOUS REPULSION AND ROTATION OF THE ARC.

and with a constant current transformer by a flexible cord, was mounted to a handle for convenient handling.

If an arc was started between the inner carbon and the concentric tube, and if the coil was approached parallel to the face of the carbons, the arc revolved around the centre carbon after the manner of a pin-wheel. Reversing the face of the coil—that is, the direction of the field threading the arc—caused an instantaneous reversal in the direction of rotation of the arc.

When the coil was placed around the concentric carbons and near the arc, the latter became distorted, as shown in fig. 2, while it continued to revolve about the axis of the coil.

Many modifications will suggest themselves to any one attempting the experiments. One point observed by Prof. Thomson was very clearly evidenced, which was that when the arc was whirling (and it might be made to whirl so rapidly as to appear continuous about the centre carbon) the potential required to maintain a constant current rose enormously, so high, in fact, that the transformer was often unable to supply the demand for increased potential necessary to maintain the arc, although it was constructed to deliver a constant current from short circuit to 800 volts; as a consequence, the whirling arc would repeatedly blow itself out with a loud report if the deflecting coil was approached very near the seat of the arc. Of course, the arc revolves and becomes distorted because of the reactions between the field produced by the coil and the weaker field about the arc, and an apparent continuous effort exists between the two fields to coincide or join together. Many beautiful lecture and demonstration experiments for classes may be obtained from this same simple apparatus, which, of course, may be operated with equal success by either alternate or direct currents.

* *Electrical World.*

COMMUNICATIONS FROM AUSTRIA-HUNGARY.

[FROM OUR OWN CORRESPONDENT.]

ACCORDING to an official despatch from Berlin, the Secretary of the German Post Office has come to an arrangement with the German Post Office to go on in the present year with the telephonic connection between Zittau and Reichenberg. This announcement involves a telephonic connection between Vienna and Berlin. A telephonic line is already completed from Berlin to Zittau, whilst in Austria the line is complete only from Vienna to Prague. The line must consequently be completed from Prague to Reichenberg, and there would only remain the construction of a line between Reichenberg and Zittau to complete the line from Vienna to Berlin. According to a communication, derived from very important circles, the telephonic connection between Vienna and Berlin will not take place so rapidly as it might be inferred from the Berlin despatch; as, in the first place, only the Reichenberg-Zittau line must be carried out in order to effect the communication between these two industrial towns across the Austrian frontier. The chief purpose of the Austrian telephonic administration is, above all things, directed to the telephonic connection between the most important towns at home before carrying a long direct line abroad. Hence Prague will be connected with Reichenberg, and Pilsen connected by a telephonic line. The telephonic connection between Vienna and Trieste is considered as the most important question, and the construction of this line will be next taken in hand.

The municipality of Agram, the capital of the Hungarian Crown territory of Croatia, has granted the International Electrical Company of Vienna the concession for erecting electric works for supplying electric currents for lighting and for the transport of power. The same town has lately granted a concession for the construction of a tramway for which electric motive power is also to be adopted.

The authorities of Budapest have instructed the office of the municipal engineer to decide as expeditiously as possible the conditions which must be laid down in the approaching public competition respecting electric lighting. This step has caused great displeasure in extensive circles of the inhabitants, as it is regarded as an unnecessary delay of the long-wished for solution of the electric lighting question. As the only point is simply to grant a concession without any limitation, so that the city can grant concessions to other applicants, the invitation to a public competition is quite super-

fluous, and it was expected that the city would at once deal with the tenders which have already been submitted. By further protracting the affair, the monopoly of the gas company will be further prolonged, and the arrangements already discussed in your paper will be formally cancelled.

In the last session of the Metropolitan Assembly of Representatives, the agreement recently concluded by the city with the Electric Tramline Company has given rise to a peculiar interpellation. The question was put to the burgomaster if he was aware that several members of the municipal committee, and in particular of the metropolitan railway committee, had been elected directors of the electric town tramline, and had conducted the preliminiminary negotiations. The querist asked whether this was not a case of incompatibility, and if so, what the authorities proposed to do in this matter. The meeting of representatives resolved to place this interpellation in the order of the day for the next meeting.

PRACTICAL PHOTOMETRIC RESEARCH.

By RALPH CONRAD RICHARDS.

Part II.

(*Concluded from page* 402.)

It has been thought that in any case automatic action is more desirable than actual visual observation, for the very simple reason that such action prevents erroneous observation due to defective sight, after the apparatus has received a thorough calibration in the manner set forth. There is no lack of seemingly possible methods to obtain such actions, although on careful analysis it will be found that nearly all of the most simple and promising methods are fraught with many almost insuperable difficulties; selenium and the thermo-pile are cases in point. The principle upon which the instrument under discussion is constructed is dependent upon known laws, viz. :—

1. All the rays throughout the visible spectrum possess a two-fold, and, in some cases, a three-fold effect (*i.e.*, an illuminative heating and chemical); the last-mentioned is almost confined to the violet portions, although the yellowish green rays are certainly the potent factors where the chemistry of plant life is concerned; this chemical effect has, however, no connection with the present subject, although it will form the basis of a later contribution.

2. The heating effect which accompanies the luminous effect is due to precisely the same rays, as has been proved by several physicists.

3. This heating effect manifests itself when light rays become incident to a solid body, more particularly if such a body be blackened on its surface. Under such circumstances, practically *all* the energy wrapt up in the rays becomes transformed into heat, for since such a surface neither reflects nor transmits light rays, a transformation of energy must occur. Now, it is well known that this transformation takes the form of neither sound, mechanical or chemical action, electrical current phosphorescence nor fluorescence, nor is it in any manner statically occluded; hence since energy is unannihilatible, heat *must* be developed; the author would not dilate upon so apparent a matter, had he not remembered to have seen in a paper in one of our technical journals a query regarding this phenomenon.

4. If an electrical conductor suffer an elevation of temperature its resistance becomes exalted in proportion to the thermal increment.

The above considerations will sufficiently illustrate the direction in which the writer has been working.

In order to verify this reasoning, a rectangular frame, 6 inches by 4 inches, was provided with metallic pegs, 10 being arranged equi-distantly from one another along one of the shorter sides of the frame; a similar course was pursued with the opposite side.

The frame then received a single winding of very thin well-annealed iron wire, which was wound spirally from peg to peg, being secured at either end; this skeleton winding then received a thin uniform coating of soot from the flame of a paraffin candle.

On placing a card before this arrangement, the resistance was taken with a Wheatstone's bridge, the card was then removed, and the rays from a paraffin lamp giving a light of very small intensity* allowed to fall upon the winding. This occasioned a slight elevation of resistance; an alum cell was then intercepted between the lamp and frame, which caused a diminution of resistance, and on replacing the card a further diminution occurred, thus proving conclusively that both dark and radiant heat (or the rays of light) occasion a rise of resistance in electrical conductors.

The curve (fig. 3) shows the distribution of heat (produced by light rays striking either a thermo-pile or an arrangement of this kind) throughout the visible spectrum.

Fig. 4 exhibits the completed instrument, the construction of which will now be explained.

Two cylindrical glass vessels are employed, one end of each is open, the other being closed by an hemispherical end, the dimensions of one vessel is 10 inches by 14 inches, and of the other 18 inches by 18 inches (the diameter of the smaller being the lower figure). These are mounted concentrically upon a mahogany ring by cementing the open ends into two concentric grooves.

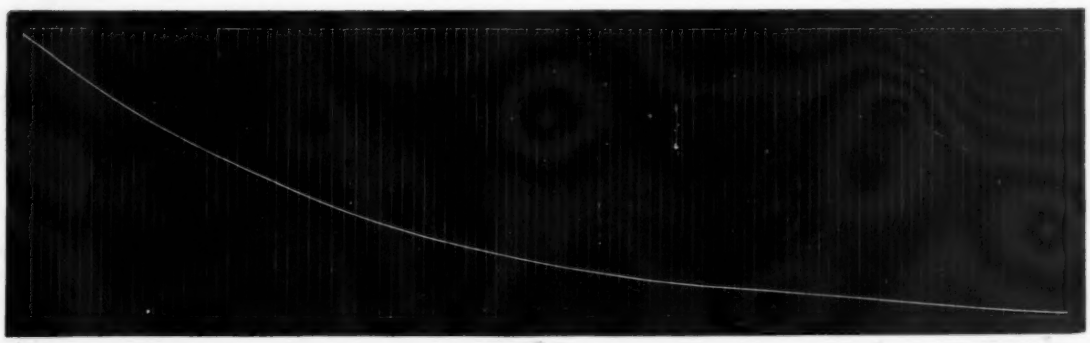

Fig. 3.

In the centre of each of the hemispherical ends is a round hole 2 inches in diameter, into which a pipe of thin material of suitable size and provided with end flanges is cemented water-tight; thus a species of tank is formed between the

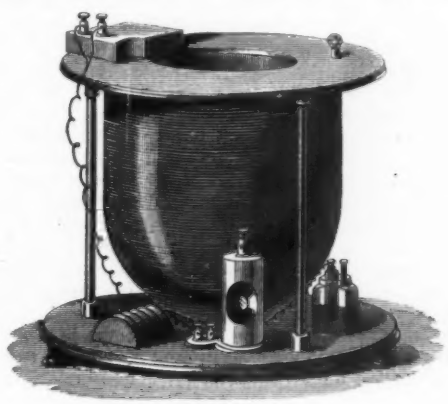

Fig. 4.

* Perhaps two candles.

two vessels; a hole provided with a glass stopper, shown in the figure, is provided in the mahogany ring, serving as a possible inlet for fluid.

A ring, 3½ inches diameter, of well varnished cane, and provided with many hooks, is fastened centrally on the outer hemispherical termination of the exterior vessel, and a similar and larger ring is secured to the outside junction of the open ended extremity of the larger glass vessel and the mahogany ring.

Well annealed, soot-coated iron wire is then wound spirally in a longitudinal direction upon the globe, from hook to hook, until it is covered with a skeleton winding (the only path for a current being throughout the whole length of the wire). A covering of blackened brown paper is placed over the entire winding to exclude exterior light, and a further covering of string (enamelled vermilion), as a preventative both of mechanical injury and of any errors arising from sudden elevation of temperature in the vicinity of the apparatus. The vessel so formed is then mounted in an inverted position upon a mahogany base board by three brass pillars arranged equidistantly around the vessel.

We are now in a position to take into cognisance *all* the rays emanating from a luminous source which is placed within the inner vessel, which may be regarded as a species of bowl, through which the rays pass to the outer vessel and consequently to the wire to produce the necessary elevation of resistance.

When the instrument is used to measure arc lamps, the tube serves as a convenient receptacle for the slide rod, and also for many other purposes—gas tubes, for instance.

In the case of incandescent lamps a silvered cone, placed over the upper extremity of this tube prevents, by reflecting those rays which strike upon its surface from falling in an inefficient position; a slight error is even then entailed owing to waste on reflection, but this is rendered insignificant when it is remembered how small a fraction of the whole emission would fall upon the reflector.*

In the case of arc lamps this error would be considerably less, for the frame of the lamp, carbon holder, &c., practically prevents many rays falling in a disadvantageous position. With the object, however, of minimising such errors, an adaptable mantle or cone, covered with bright foil, is provided; this will readily adapt itself to almost any surface. As the dark heat radiation emanating from the illuminant would entail error, the interval between the inner and outer vessel is filled with a concentrated solution of alum in distilled water, to which is added carbolic acid, in the proportion of one part of acid to every 1,500 parts of water, as a preservative. To ensure the uniform transmission of the rays, the inner globe is ground on the inside surface; thus the necessity of literally covering the outer globe with spires is obviated by the great dispersive power gained.

Another piece of apparatus requiring description is shown, fixed on the top of the mahogany ring, the purpose of which is is to determine the illuminative *quality* of the light under consideration; the lamp is lowered until in front of an alum cell, which constitutes the front portion of the apparatus. This is about 3½ inches deep, to correspond with the thickness of the great cell, *i.e.* (the interval between the globes). The rays are here split up, the luminous and chemical radiation *only* passing through to a condensing lens, and thence to a further lens which passes them on nearly parallel through a narrow slit to a flint glass prism, whose dispersive power equals the one employed in the calibration experiment.†

On leaving this latter, according to their wave lengths, the rays diverge to a screen at the back of the apparatus, all of which is arranged in a mahogany cell of suitable shape.

The screen consists of a little frame, similar to the one employed in the preliminary experiment, but differing from it in geometrical dimensions, which are 2½ × 1 inch (in height); the spires, too, are closer there, being about 150, arranged vertically throughout the whole length.

Reference to fig. 5 shows the principal points of a Wheatstone's bridge (as illustrated in most elementary text-books); the bridge is connected up in circuit with the usual galvanometer and cell.‡

* The error due to the non-employment of mirror.

† It is safer to employ the same prism.

‡ Owing to a possible source of error rendered apparent on consideration of the law of Joule, a battery, developing but feeble current, should be used in conjunction with a very sensitive reflecting galvanometer.

Firstly, let members A B and A C consist of equal resistances; into B D is inserted the little frame just described, and into C D a resistance of the same soot covered wire similarly wound on a frame, but placed in the same chamber in a partitioned part, *to which the light rays cannot obtain access.*

An adjustable resistance is placed in series with this latter in C D. Now, since both frames are in a chamber where the temperature is common to both, and have the same temperature coefficient, the exterior temperature cannot affect the arrangement. On the rays impinging upon the frame inserted in B D (fig. 5) the elevation resistance, due to the heat developed by the light rays, causes a deflection upon the galvanometer; this is then eliminated by the adjustable resistance, which is then switched out of circuit. Since, however, the resistance introduced in the arm, C D (now switched out of circuit) is not a measure of the light before the apparatus but of the heat, the various rays develop on striking the frame (which a comparison of curves 2 and 3 shows to be utterly disproportionate to the luminous power of those rays), it is plain that further aid is required.

On using the two curves for comparison, let the highest

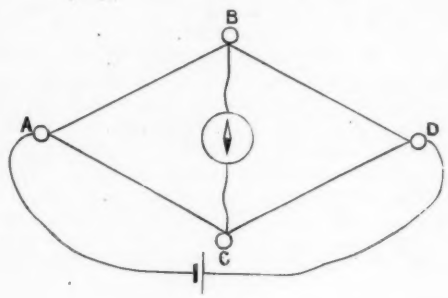

FIG. 5.

light ordinate be taken and represented in imagination by a certain amount of heat developed, it is evident, then, that any light ordinate being taken, should be represented by an amount of heat bearing the same ratio to the heat developed in the imaginary example as the latter light ordinate does to the former. To accomplish this, a comparison of the curves should be made, from which it will be seen that one special light ordinate has a less corresponding heat ordinate than any other. This is chosen from the rest as a standard for reasons soon rendered obvious. The problem is to draw a number of ordinates (in which the heat will in all cases be proportionate to the light) from the two curves. Now, these ordinates are gained by supposing that the heat represented by the heat ordinate affects a thin wire 1 inch in height. What is required is to screen off so much heat that the remainder shall bear a constant proportion to the intensity of the light producing it.

Taking the standard instance previously cited, it is found that the light = 3 and the heat = 1. As this is the standard instance, this particular wire is left open, *i.e.*, unscreened. Another wire is taken; here light = 7 and heat = 4. Since the 1-inch wire in this case receives more heat than the standard in the ratio of 4 to 1, *one-fourth* of the total length would represent a quantity of light equal to the standard; here, however, the light is = 7, whereas in the standard instance it only equalled 3, thus the necessary opening will be

$$\frac{\left(\frac{1}{4}\ \omega\right) 7}{3};$$

where ω equals the length* of wire (in this case one inch). Now, on applying this principle throughout the curves a new set of ordinates will be obtained, of which the above are two examples.† A curve is then drawn, and all the portion contained betweeen the boundaries formed by the abscissæ and this curve blacked out with Indian ink; a negative of this is obtained on glass by the aid of photography (the same size),

* Hence screened off portion = $\frac{1}{12}$th inch.

† These are, of course, merely illustrative of the method, the practical solution being hampered in most cases with fractions; the curve is in reality drawn 10 times the size indicated above.

and when placed before the frame upon which the light falls, will by screening off the correct proportions of any rays give a correct indication electrically of the intensity of any light, however brilliant, and quite independently of its spectral composition. Another adjustable resistance is switched into C D (fig. 5), and adjusted, this is then switched out. As both measurements are taken in quick succession, no error arises from temperature, as both have the same temperature coefficient. The lamp is next lowered into the bowl, and the proper precautions taken (a mantle of blackened asbestos tied around the lowering rope which passes over a pulley in the ceiling is arranged to drop cloak-like over the top of the apparatus, thereby rendering all these operations possible in open daylight); the spires surrounding the outer vessel are inserted in B O, and a resistance equal to them in the dark, and having its temperature coefficient equal, is inserted in series with an adjustable resistance (in this case of platinoid) in C D; balance is now obtained, and the adjustable resistance is switched out. Next, the first adjustable resistance, representing the total heating effect of the light rays from the lamp is inserted in A B, the second adjustable resistance in B D.

Thus expressing a tangible ratio between the total heating effect of the luminous rays and the heating effect in proportion to their luminous power, it is obvious that if the last adjustable resistance employed be inserted at A C, on balancing a measure expressing the total luminous power of the lamp has been obtained. It is still necessary to know what this amounts to, therefore the last resistance, which is on the sliding contact principle, has been graduated in units of resistance, equal to the rise of resistance caused in the apparatus by a light of one candle-power, the remaining possible cause of error is due to temperature, which, by elevating the resistance of the last adjustable resistance, causes the value in candle power (reading from the sliding contact scale) to appear too small; this could be eliminated by calculation, or more readily by inserting several wires (in shunt with the adjustable resistance), varying in resistance in order that the conductivity could be increased as required by the elevation of temperature; the movable contact of the adjustable resistance would travel over these in common with the wire of the graduated resistance. In conclusion, it may be said that an instrument is now in existence which combines:—

1. Ability to measure accurately lights of any intensity or spectral composition, (2) direct reading, (3) non-cumbrous, and (4) independently of external conditions. As these are the advantages, it is only fair to admit the disadvantage, which, though capable of correction, still exists; this is the time taken over each measurement, due to the thickness of iron wires, necessitating a pause, during which they attain their maximum temperature. As there are several matters still requiring completion, the subsequent articles will be divided into two portions, the first dealing with measurements conducted without, and the second with the apparatus in question.

THE ELECTRIC ARC AND ITS USE IN LIGHTING.*

By ELIHU THOMSON.

(*Concluded from page* 400.)

It has been supposed by some electricians that there existed a peculiar fitness for arc lighting in series in dynamos of the open coil type, such as the Brush or Thomson-Houston, over those of the closed coil types, such as the Gramme or Siemens forms. Whilst, personally, I have never been prepared to admit this peculiar fitness, constructors of machines of the closed coil types have certainly succeeded in removing any doubts on that score. Mr. J. J. Wood has, in building his form of Gramme machine up to the highest capacities for series work, taken a leading position in this respect. In fact, the simplicity of the commutator and the ease of insulation of machines of the open coil type undoubtedly rendered them more capable of retaining insulation at high potentials than the early commutators with numerous segments used on Gramme and Siemens machines, as such commutators were at first constructed. Likewise, improved methods of insulation and winding have gone far to put both types of machine far in advance of what they were formerly. While on this subject of arc machines, it may be well to say a few words as to the action of flashing, which can occur in all machines of high potential under certain conditions. In the first place the term flashing, as here used, is not intended to refer to sparking at the commutator, but rather to a flash or continued spark carried over during revolution of the armature from one brush towards the other, either all around the commutator, or part way only. This action occurs when any two successive segments in the commutator continue their discharge one towards the other over the insulating space between them during a considerable part of the revolution. An arc forms in the slots or between segments, and moves with them. This action, while not very damaging where the segments are massive and insulated with air spaces, is more serious with insulation filling between the segments, as it is apt to cause a burning out, and either short circuits the armature coil sections by connecting the segments, or seriously roughens the edges of the segments and the face of the commutator.

Bad setting of brushes may cause both sparking as well as flashing; and dirt, in some cases, or too much oil, may cause it. Slipping of belts or sudden fluctuations of speed may also provoke it. Or a machine, overloaded, may flash by an opening of the circuit due to too many lamps, the electromotive force required for which number the machine can not maintain. The presence in a circuit of one or more lamps which do not feed properly may cause momentary cessations of current and flashing to occur, especially when the machine is carrying its full load. With all arc circuits there should, of course, be a surplusage of capacity in the dynamo, *i.e.*, the machine should not be run to the limit of its electromotive force. It has become customary with the best makers to so rate this capacity that there will always be a margin of excess to meet contingencies. The line resistance may, of course, be, in the case of long circuits, such as to cut down to a considerable extent the working capacity or number of lamps in series which can be run from the dynamo, and due allowance should always be made for this resistance in estimating the true capacity. Instances are not uncommon in which by improving the contacts of switches, hangers, joints, &c., a gain of two or three lamps may be made in circuits of fifty or more lamps in series. An improvement in the insulation of a line will often have a similar effect in adding to the apparent capacity.

I had intended at the outset of this paper to discuss in a general way the question of the different types or classes of lamps used for arc lighting. It is a department of the subject which is of considerable importance, but I find that the paper has become too long already, and for the present I will simply allude to one or two general features. Concerning the manner of feeding the carbons, the mechanisms in use may roughly be divided into clutch and gear mechanisms. Among clutch mechanisms we find certain well known forms while the gear mechanisms best known are of the escapement order. Both types have undergone many modifications, and combinations of the two exist.

Whether one or other type is to be selected will depend largely on the conditions of use, assuming both to be equally well constructed and kept clean. Into these questions, however, we can not now enter.

Arc lamps may also be divided according to the way in which the magnet system acts to control the feed of the carbon. Before arc lamps were run in series it was sufficient to have the controlling magnet in the main circuit, and this was the case in almost all the older forms of lamps. The Lacassagne and Thiers lamp of 1856 was a notable exception in that the control of the feed was differential, or dependent on the difference of power between a main circuit coil and a high resistance shunt circuit around the arc.

I have, in fact, made an exact reproduction of the Lacassagne and Thiers lamp according to their patent specification, and have found that its action is perfect when used in series with other lamps, except that it requires to be helped to separate its carbons. If the carbons are quite pointed at the start, even this is unnecessary, as the points soon heat and burn away and form the arc. The feeding depends on the flow of mercury through a small valve, which is adjusted by

* Read before the National Electric Light Association, February 18th, 1891.

the differential magnet system, and the feeding is so continuous and imperceptible, that the arc is beautifully steady and constant in length.

At the present time the differential lamp magnet system is of several kinds, according to the relative disposition of the main and shunt coils.

In the commercial Brush arc lamp they are disposed one over the other on the same axis, and affecting the same magnetic cores. The only objection to this disposition, which has the advantage of simplicity, is that the shunt circuit can never act positively to feed the carbons or release the clutch or gear, but can only weaken the effect of the main coil, or overpower its lifting or separating action on the carbons.

Other forms of differential lamp embody two circuits acting on separate magnets pulling in opposite directions, the main circuit to separate the carbons, and the shunt to feed them. In this case the action of the shunt is more definite and positive, as it is not limited simply to overcoming the force of the direct or main magnet.

A third arrangement involves the application of the repulsive action of the two coils, as when the direct coil is wound on a fixed magnet, and the other, or shunt, upon the feed controlling armature therefor, and tending to cause repulsion of the armature from the main magnet. This arrangement is both simple and positive in its action.

The differential types of lamp act well when the circuit current is kept constant, and require readjustment generally for each change of current strength by which they may be operated. Hence, if a portion of a line be leaky, the lights are apt to burn badly, owing to diminished current, while the dynamo may be furnishing full current. Of course, such a line ought to be condemned, and its insulation improved. Nevertheless I have frequently seen lights suffer from leakage on extended circuits in cities, especially in very wet weather. This is a state of things which the line superintendent can do more than any one else to correct, by attending to the correct disposition of the wiring, and its character as regards leaks.

The type of arc lamp in which the shunt magnet alone controls the feed of the carbons is not sensitive to slight variations of current, but maintains a full quiet arc with the current it gets. This is because the main current is not concerned in the feeding action, but the action is solely dependent on the potential difference of the carbons. Hence its behaviour is on the whole more uniform than the differential type, and within limits it does not require readjustment for different current strengths.

This principle has been extensively introduced in the Thomson-Rice lamp of the Thomson-Houston Company. In this lamp the carbons are separate at the start and are brought together on the first passage of the current, after which they separate solely under the influence of the shunt circuit magnet and the feed is likewise controlled thereby. The carbons in these lamps are not so apt to slide by, or alongside, each other by jarring when no current is on the lamp, as may occur, particularly with careless trimming, in those lamps in which the full weight of the upper holder and carbon must be borne by the under carbon when the lamp is not lighted.

Arc lamps have been made with many variations in the magnetic arrangements controlling the carbons, a brief statement of some of which is as follows :—Carbons lifted or separated by direct or main magnet; shunt magnet acting on a variable resistance to cut out the main magnet in feeding. Carbons lifted by main magnet as before and shunt acting to put the main magnet (made movable) into position for feeding.

Carbons separated by main magnet armature; shunt circuit magnet acting to divert or shunt the magnetism of the main magnet from its armature.

Carbons separated by main magnet and shunt acting to free the carbon holder independently of the support given by the main magnet.

Carbon separated by a spring and allowed to act by the main magnet lifting a weight which otherwise holds the spring from acting; shunt magnet acts against the spring to feed and regulate length of arc.

One carbon, generally the lower, separated by main magnet, while the other holder is released for feeding only, such feeding being under the control either of a differential system or a shunt magnet only.

Carbons separated by main magnet which lifts the shunt and its armature together, while the shunt magnet armature, acting on the feeding mechanism, controls the arc and feed of the carbons.

Carbon feeding mechanism independently attached to main magnet armature and to shunt armature, so as to receive opposite movements of separation and feed from each respectively.

Carbons separated by a feeding mechanism moved by the main magnet and fed by a further movement of said mechanism causing release or return of same under the accumulated force of both shunt and main magnets acting in the same direction.

Differential clock gear for separation and feed of carbons under control of the regulating magnet system either simple or differential. Some of the older clock-work lamps embodied this principle.

Carbons controlled by armatures of a small electric motor under control of a differential field which turns the armature in one direction for separating, and in the other, or reversed, direction, for feeding the carbons. Tchikoleff's early lamp was of this type.

Carbons controlled by a motor running at a certain speed, when the arc is of normal length and varying in speed, when the arc is too long or too short, combined with a centrifugal governor on the shaft of the motor acting on variation of speed to gear motor shaft to screw carbons together or apart, as needed, to maintain the normal arc. This mechanism has been applied by me to large arc lamps such as naval search lights, and has the advantage of great positiveness and an ability to handle heavy mechanism.

There are also a considerable number of modifications from these principles stated which cannot be referred to here.

Another excellent mechanism and one of the most powerful and positive in feeding the carbon, embodies a main magnet separating the carbons and striking the arc, and an intermittently acting shunt magnet for working a pawl, which, by a suitable gearing, forces the feeding action or approach of the carbons as required. I have used an endless screw gearing with the pawl, acting on a ratchet wheel to turn the screw, the worm wheel being on a shaft carrying a pinion meshing into a rack on the carbon rod. The worm wheel gearing is lifted by the main magnet to strike the arc, and the shunt magnet in operating its pawl breaks its own circuit and repeats its feeding action as often as may be necessary.

It is interesting to note in this connection that I have built such lamps in which each feeding movement of the carbon is not over $\frac{1}{10000}$th of an inch, and that if the upper carbon rod is held in a vice the mechanism will hold the whole lamp of about 20 lb. weight in feeding, so positive is the action. At the same time, the length of the arc is maintained constant at all times. With so slight and yet positive a feeding action, the feed takes place almost continuously.

In the foregoing brief review many matters have been simply touched upon which might readily have been singly expanded into a paper as long as the present one. Material enough now certainly exists, and could be collected, for making a good technical work dealing with the science and practice of arc lighting. My purpose will have been fulfilled if I have succeeded in the present paper in adding some things of interest and instruction concerning this general subject from the standpoint of one who has constructed very many forms of apparatus for arc work, and who has had a continuous and growing experience with such work from its beginnings up to the present great commercial expansion.

Gadot Accumulators.—An expert's report has been prepared for M. Gadot, regarding his secondary battery. The report deals with the claims made for various accumulators, and the conclusions are that M. Gadot has not infringed the Faure, Volckmar, or Sellon patents. It will be remembered that the Société Française d'Accumulateurs Electriques commenced actions against certain makers of accumulators, for infringement of patents, and among whom M. Gadot may be included. This gentleman, is, however, said to be prepared to substantiate his claims in the French law courts.

ELECTRIC LIGHT WIRING INSTALLATIONS FROM A MECHANICAL STANDPOINT.*

By AUGUSTUS NOLL.

The question is frequently asked by architects and owners of buildings, "Can electric lights be installed with safety from fire, and will the installation give results that are satisfactory, and permanent?"

The improvements made recently, in materials and methods, admit of answering in the affirmative.

Nearly all the troubles in electric lighting plants have been caused by defective wiring, and on that part of the lighting system, more than on any other, depends the success of future service.

It may not be amiss to compare the early date of the art of electric light wiring with the present, and the probable future advancement in the methods of installation.

In the early days of electric lighting, a wire, covered with cotton, and saturated with paraffine, was used; this in a short time was replaced by a wire covered with cotton and white lead, known as "underwriters' wire;" the insulation was supposed to be fire-proof, and on that account, decreased the chances of fire; while the insulation was non-inflammable, it also readily absorbed moisture, which caused excessive leakage and some incipient fire; a few carefully conducted tests and experiments, proved that "protection against moisture was prevention of fire," and henceforth a moisture-proof wire was demanded, and the manufacturers in that line now offer us such high grade insulations as "Grimshaw White Core," "Okonite," and others.

Improvements in the method of installing the wires were also made; formerly buildings in the course of erection were equipped with the fire-proof insulated wire encased in wood mouldings, or inserted in zinc or lead tubes, but with the appearance of the moisture-proof insulated wire, the former insulation was discarded for the latter, and instead of inserting the wire in zinc and lead tubes, it was fastened directly to the side walls and ceilings, and covered by plaster. The cut-outs and switches are now mounted on porcelain and slate, instead of wood as formerly. More attention was given to the equalisation of electrical pressure on conductors.

While these changes helped to improve the work, it was still a matter of chance that wires placed in a new building and imbedded in plaster gave satisfactory results; conditions that could not be controlled, increased the difficulties. A cut from the plasterer's trowel or a blow from a hammer on the insulation, destroyed its utility; and though the wires may be tested, the fault in some cases would not appear till the building was completed, when, to remedy the defect, it was necessary to cut the plaster to obtain access to the wires, or discard the faulty circuits and re-wire on the surface of the plaster, in either case disfiguring the walls and causing extreme annoyance; again, should changes be contemplated in the wiring, such as an increase of lights on different outlets, or a change to a lighting system where lamps of a lower voltage are used, we are once more confronted by work that is totally inaccessible, and to make the changes required, are forced to have recourse to the same expedients as stated before, and with the same results.

Although wiring installations gave better results than formerly, there was yet a large field for improvement; access to the conductors became absolutely necessary for controlling the system, making changes and recctifying defects which may occur after the work is finished and the building completed, and to do so without cutting or defacing the walls, or interfering with the other portion of the lighting system.

It is evident that as long as the conductors are inaccessible, just so long will the results be uncertain, and as it is our aim to eliminate the objectionable features and secure a wiring system that possesses accessibility and freedom from fire and leakage, the question is: "What is necessary? To which I reply: A high grade moisture proof insulated wire together with a system of "raceways" or conduits, and a complete line of "fishing" or junction boxes.

The conduits should be of ample size, with smooth inner surface, so that wires can be easily inserted or withdrawn; they should be constructed of materials that will not stain nor exude through plaster or paint, and should be non-combustible and moisture-proof; the action of lime or cement, or extreme variations of temperature should have no effect.

The "fishing" or junction boxes should be equipped with shoulders or sockets for the entrance of the tubes, thereby making them a part of the conduit system, and preserving the continuity which is so essential in a system of this kind, and also enabling us to make the joints moisture-proof.

All cut-outs when single or in groups, should be located in the junction boxes.

The conduits should be installed in a workmanlike manner; they should not be run or looped from one outlet to another, but branches should lead to each outlet from the main conduit carrying the wire for that circuit, and at right angles with same; at the intersection of the branch and main conduits, a "fishing" box should be placed; the main conduits may be located in the cornice near the ceiling, or behind the base board at the floor with the cover of the junction box flush with the surface, thus keeping them out of sight and at the same time easy of access. The location of the conduit should be uniform on the different floors throughout the building.

An extra covering of metal should be placed on the conduits at the outlets, to keep them securely fastened to the wall, protect the ends, and take off the strain when inserting or withdrawing wires.

With a proper conduit and a complete system of junction boxes, it becomes unnecessary to insert a single wire (with the exception of the main feeders) until after the installation of conduits is complete, and the building finished; the insertion of strings or drawings lines is equally unnecessary, for, should the string or wire break near the middle of its length, that circuit would be as inaccessible as though it were imbedded directly in the plaster.

The main wires can be inserted in the conduits at the time of installing same, and placed in recesses in the walls, the cover of the recess to be detachable.

In hotels, apartment houses, office buildings, and other structures used for similar purposes, the largest part of the wires and conduits, together with the cut-outs and junction boxes, can be located in the halls, so that in case of alterations or additions being required, the occupants of the rooms will not be annoyed.

Considering the advantages a wiring system of this kind possesses over previous methods, a comparison in cost will be favourable to the conduit system.

The indefinite manner in which electric light wires are sometimes installed, has often placed the owner of a building, who contemplates changes, at the mercy of the company or contractors, under whose supervision the work was installed; they in turn delegate the foreman who had charge of the work in that particular building to attend to the changes required, and he usually tries to obtain the services of some of the wiremen who worked on the installation, because "they know where the wires lie."

It is apparent that the employment of a complete conduit system obviates these troubles, and also that instead of equipping a building with a wiring system suitable only for a special company's system of lighting, it can be fitted with conduits for electric lighting, regardless of system, and in fact, similar to piping the building for gas; and should a change in system be desired in the future where lamps of a lower voltage are used, the change can be made without cutting or defacing the walls, and at a nominal cost, whereas, should this change be required in a building where the wires are imbedded in plaster, it would practically necessitate the rewiring of the entire plant, and at a cost at least equal to that of the original work.

While a conduit of good insulation is necessary, it should not be regarded as extra insulation or protection, to an extent where the insulation directly on the wire is decreased, it should only be treated as a medium to accessibility.

"Prevention is better than cure," and for that reason only one wire should be placed in a conduit. Although the fusible metal cut-out will usually break the circuit in case of a "cross," still, it is safer to guard against any formation of this nature, by placing each wire in a separate tube, than to invite it by insufficiently insulated wire, or inserting wires of different polarity in the same tube.

Only the best is good enough, and will in the end be the cheapest for all branches of electric lighting.

* Prepared for the National Electric Light Association, Providence, R. I., February, 1891.

The co-operation of architects is not only desirable, but necessary for the future advancement of electric light installation work, and to their credit be it said, that they are ever ready to extend their help; already have their suggestions been of value to us, and should the necessity of securing separate recesses be explained, they will, without doubt, make provision for the work similar to that made for gas, steam, and water pipes.

THE EFFECTS OF REPEATED FUSION ON THE ELECTRICAL PROPERTIES OF AMALGAMS.

WHEN various alloys are repeatedly heated and as often cooled, their physical properties undergo considerable modification. This fact has been known for a long time, and has provoked much speculation and experiment. Many instances of an alteration of properties under such conditions will at once suggest themselves to those who are at all acquainted with the subject.

Mr. G. Gore has recently been examining the change in electrical properties which amalgams undergo when subjected to repeated fusion. As an example, we may cite the phenomena observed with cadmium amalgam.

An amalgam was formed consisting of four parts of mercury by weight to one part by weight of metallic cadmium. A voltaic couple was used, composed of this amalgam and a strip of platinum in a solution of common salt (one part), and distilled water (one hundred parts).

The electromotive force of such a voltaic couple was found to be reduced when the amalgam was subjected to repeated fusion. This diminution proceeded until the fifth fusion, after which the electromotive force was observed to be constant, in spite of renewed fusions.

The amalgam also changes in volume concurrently with this change in the electromotive force. Determination of the specific gravity gave the following value:

After the first fusion	...	12·5438 at 14°·5 C.
„ fifth „	...	12·6190 „

A similar change was also found to take place spontaneously in the freshly prepared amalgam. A diminution in the electromotive force took place during the first few days, and was observed by the same method as that described above; it clearly indicated a spontaneous molecular change in the amalgam.

Mr. Gore concludes from these experiments that by the act of fusion and subsequent cooling, and by spontaneous change, the amalgam suffers a loss of molecular motion, potential heat, chemical activity, and voltaic energy: further, that it diminishes in volume, and becomes less liable to be corroded when exposed to the action of a solution of common salt. All these changes appear to be of a permanent nature.

LONG-DISTANCE TELEPHONE SCHEMES.

WHEN the City and South London Railway was inaugurated, schemes for similar undertakings were advanced in Austria-Hungary, Germany, and Belgium. By a peculiar coincidence, the successful completion and commencement of the London-Paris telephone service have caused, with one exception, the same continental countries to advance projects of a like nature—in the case of telephony. One scheme is for the establishment of telephonic communication between Berlin and Vienna, and another for a similar connection between Ostend and London.

In German official circles it is announced that the German and Austrian Governments have arrived at an understanding regarding the institution of a telephone service between Berlin and Vienna, which is to be effected before the termination of the present year. Berlin is already connected as far as the town of Zittau on German territory, and in order to complete the proposed Berlin-Vienna line it will only be necessary to extend the service from Zittau to Reichenberg, and from Reichenberg to Vienna, *viâ* Prague.

In Belgium the large commercial and financial firms are asking whether it would not be advisable to establish telephonic communication between Ostend and London by means of a submarine cable from the former to Dover and from the latter town to London by a land line. The Post and Telegraph Department is already considering the question, but, before any definite action is taken, the working of the Paris-London line will be closely watched, so that the Belgians may profit by the experience which will accrue through the operation of this service. It is believed that notwithstanding the great expense incurred in bringing the Anglo-French telephone line to a successful issue, the service will, seeing that 10 francs is now charged for three minutes' conversation, be commercially successful.

It is proposed either to ask the English and French Governments to grant permission for a trial to be made to speak from Brussels to London, *viâ* Paris, or to allow of a supplementary circuit to be joined to the Calais-Dover cable, whilst Brussels would be connected with Calais by an overhead line, or to lay a cable from Dover either to Ostend, Nieuport, or to La Panne. Four towns are particularly interested in the provision of direct communication with London. These are Antwerp, Ghent, Verviers (which has daily business relations with Manchester, London, Birmingham, Liverpool, and Glasgow), and lastly Brussels. It is estimated by the Belgian Post and Telegraph Department that the cost of establishing the service could be covered.

If the proposed Brussels-London line be successfully carried out, a telephonic service is projected between Holland and Belgium. This would place Antwerp in direct communication with Rotterdam and Amsterdam, and Amsterdam with Paris *viâ* Brussels. Some years ago the erection of an overhead line between Verviers and Aix-la-Chapelle was commenced, but it was not completed, owing to a prohibition being issued from Berlin. This order was due to the action of one of the chief postal officers who received from a neighbouring country a telephone message in insulting language to himself and to Germany. Then the German Government decided for the time being to sever its international relations by telephone.

MANGANESE IN CELLS OF THE LECLANCHE TYPE.

FOR working electric bells and telephones, and also to a limited extent in telegraphy, the zinc carbon cell invented by Leclanché has been found a very effective agent. The exciting fluid is, as everyone knows, a solution of sal-ammoniac, and to prevent polarisation the carbon plate is usually packed inside a porous vessel with powdered binoxide of manganese and fragments of carbon, or the binoxide is applied in a conglomerate attached to the face of the carbon thus avoiding the necessity of using a porous inside cell. These are the most common devices for destroying polarisation, and it is commonly supposed that the binoxide of manganese is the effective agent in this destruction of polarisation.

A letter from Mr. T. H. Nash, in the *English Mechanic* for March 27th, seems disposed to question this commonly accepted idea. He states that for the last four or five years he has been ringing bells with cells of the Leclanché type which contain no manganese, and that they have done their work well. He has tried broken carbon placed in a calico bag surrounding ordinary Leclanché carbon with leaden cap, the zinc being in the usual form of a rod; this gave good results. Another form which seemed to give more current was used in which the zinc was placed in the porous pot and the broken carbon outside.

The best results are stated to have been obtained by using two carbon *plates* about 2½ inches by 4½ inches with a zinc *plate* between them, sal-ammoniac solution being the exciting fluid. Two such cells as these were in use for 16 months, and all the attention they received during that time was the addition of water to make good the quantity evaporated. At the end of this period they were still in excellent working order; in fact, it is stated that in Mr. Nash's experience cells have never been known to fall off in efficiency so slightly in such a length of time.

He further says: "I have come to the conclusion that by using carbon plates and having no granulated carbon or porous pot high up in the cell, the creeping tendency of the

salt is much reduced, and I am inclined to think that it is the creeping of the salt which, more than anything else, short circuits a cell, and so shortens its useful existence." None of the cells referred to had any manganese in them, nor was a porous pot used in doing any actual work.

Mr. Nash then describes how, having once connected the zinc and carbon by a wire, and left the cell thus all night; in the morning it had "run down," and would not ring a bell at all, nor was there any sign of a current; but after resting until five o'clock in the afternoon it rang the bell as strongly as ever. He seems to think that the resistance of these cells must be low, and must keep low, and that this may account for their lasting power.

It is a pity that Mr. Nash has made no quantitative expements; he appears to have made no measurements of the quantity, or of the electromotive force, or anything else. These empirical experiments possess, of course, a certain value, but their value might be wonderfully enhanced if reliable quantitative information were forthcoming as to what seems to us the most elementary condition of any experimental work.

THE LONDON-PARIS TELEPHONE. WILL IT PAY?

Viewed from a purely scientific standpoint, there is not the slightest doubt about the success of the international telephone line which has recently been inaugurated. Calculations based on experiments made some time ago, had shown it to be possible to speak between the French and English capitals, if suitable lines were available; the money was forthcoming, the necessary lines were erected, and the ease with which conversation has been carried on has proved that the calculations were correct. Of course the experiments so far have been conducted under the most favourable conditions. The weather has been all that could be wished for, the lines and apparatus are in the pink of condition, and have the advantage of careful nursing from some of the best engineers on both sides of the channel. But even under ordinary circumstances we have no fear but that speech will be clear and satisfactory; that is to say, the result will be success from a scientific point of view. We make this reservation advisedly, because it does not follow that the experiment will be equally satisfactory when considered as an *engineering* enterprise. The scientist does not descend to such a question as that of pounds, shillings and pence, but the engineer must do so. The former simply aims at making a new discovery, or attaining a result hitherto unachieved, but the latter must guarantee that when his work is completed, the benefits to be derived therefrom, or the profits accruing thereto, shall be commensurate with the expenditure.

To illustrate our meaning, we may mention the problem of electrically lighting a scattered district. Almost anyone could do this on a low-pressure system, for instance, by using enormous mains, and thus avoiding well-known difficulties. From a purely scientific point of view, the work would be successful because the district would be lighted, and the light would be good; but as an engineering effort, it would be a failure because it would not pay. An engineer would have to carefully select his system, and calculate the size of his mains and machines, and determine their routes and positions in such a manner that the lighting would be good, while the expenditure would be sufficiently small to allow a profit to be made. Now, the telephonic experiment under consideration cannot be said to be a successful engineering feat until it is shown that the additional revenue derived therefrom is sufficient to cover the cost of maintenance of the lines and apparatus, the other working expenses, and also to pay a fair percentage on the whole of the capital sunk in the scheme.

Let us briefly glance at the chances of success. To begin with, the service must be good and reliable in order to attract and retain a steady, constant traffic. We have little apprehension on this score, except as regards the maintenance of some sections of the land lines, in which, of course, there will certainly be breakdowns from time to time. It may be remembered that in the series of articles recently published entitled "Storms and Telegrams," it was emphatically laid down that important land lines should be divided into sections and led into a number of testing stations, in order that the locality of any fault might be quickly discovered and the fault removed, and also to enable the section containing the fault to be replaced for the time being by a portion of a less important or an idle wire.

It is impossible to deny that this is sound practice, but it does not appear to have been followed in the case of the new telephone line—at any rate, on the English side—for we believe that there is not a single testing station between London and St. Margaret's Bay, where the land line joins the cable. If this be so, we fear that it will not be possible to promptly remove any fault or breakdown which may occur; and should the copper line be broken down, it will be useless to attempt to temporarily replace it by iron wires between London and the cable end, for speech would not then be possible. We trust, however, that this state of affairs will speedily be altered, and turn now to the consideration of the case, supposing a reliable service to be assured. In the first place, what is the income which may fairly be expected, supposing that all goes well? Two lines are required for one telephone circuit, and the charge for the use of the circuit for three minutes is eight shillings, so that it is possible for the two wires to earn £8 per hour. But as some time must be lost, it will probably be a rare occurrence for this maximum amount to be earned in any single hour, and it would be unsafe to estimate for a pressure of traffic for more than two or at the outside three hours during the busy part of the day. If the takings for one circuit average £30 during the 24 hours, probably everyone concerned will be satisfied. But how much of this £30 can be reckoned as clear profit? It is impossible to say, because among other things it is difficult to estimate to what extent the revenue will suffer in other directions. For example, if stockbrokers make liberal use of the new means of communication, the number of telegrams despatched by them will be considerably less than at present, and this may mean throwing several telegraph lines more or less idle. It is evident that unless the telephone creates a business of its own every three minutes' conversation will mean the loss of at least two telegrams, which, averaged at say 12 words each, reduces at once the legitimate revenue from the telephone by at least 50 per cent. But we fail to see where the new business is to be created unless the number of telephone lines is considerably augmented and the charge for a conversation made more nearly equal to that for a telegraphic exchange. There is already considerable perturbation in the ranks of the stockbrokers, who view with dismay the prospect of the possibility of a clique securing possesion of the telephone circuit for a period long enough to manipulate the markets It is apparent that the nature of their business demands the provision of sufficient accommodation to put them all on equal terms.

Again, with regard to the suggestion to utilise the telephone at night time for press work, this would only be done at the expense of the telegraph, for we believe that there is no dearth of telegraph wires at such hours, and that the daily papers have already as much continental news as they can find room for.

But difficult as it is to estimate the actual increase in revenue resulting from the new venture, it is even more so to arrive at the actual cost of erection and the cost of maintenance. The work being carried out by existing telegraph administrations, employing telegraph appliances and officers, it would not be possible to separate the expenses. But it is safe to say that the expenditure up to now has been many, many times the sum mentioned in some of the non-technical journals. The dimensions allowed throughout are "magnificent," and the material employed is good; and all this means money; in fact, we doubt whether, when the whole of the four-wire line has been erected, the cost will have been a farthing less than £70,000. We do not for a moment suppose that any dividend-earning private company would go to the expense of erecting such a line, and it is matter for congratulation that the two Governments concerned are sufficiently enlightened and generous to make such a handsome public present, or rather to spend the public money so well; and it will be regrettable if the only class deriving any material advantage therefrom should prove to be the stock-broking fraternity.

In making comparisons, it should be remembered that only one line wire is required for an ordinary telegraph cir-

cuit," and that comparatively inexpensive in material and construction; the maximum amount which a telephone circuit can earn is definitely fixed, and cannot be increased unless the charges are increased (at the risk of making them prohibitive), while it is difficult to limit the amount of traffic which can be disposed of on a telegraph circuit, for it is always possible to improve the output of the apparatus and the skill of manipulation.

While it is therefore doubtful whether the lines can be made to add to the revenue if worked simply as telephone circuits, we must not lose sight of the fact that there is a chance of their being used for telegraphy and telephony simultaneously. This method of working is extensively employed on some parts of the Continent, and no doubt could be successfully applied in the present case. If the self-induction in the telegraphic part of the circuit is by artificial means made sufficiently high to obtain absolute silence in the telephone, then the former system must suffer to a certain extent. But it is, nevertheless, possible to work satisfactorily when rapid pulsations or alternations of current are not required to be transmitted by the telegraph, and in the present case we should imagine the problem is rendered much easier by the low line resistance which will allow a very low battery power to be employed, and so reduce the amount of interference in the telephone. But here, again, supposing complete success to be attained, the gain will be little unless there should arise a demand for increased facilities sufficient to fill both the new and the previously existing circuits.

In conclusion, we may remind our readers that speech by telephone is practicable to any distance within reason if sufficient funds be available to provide a suitable line, and if it be not absolutely necessary for the enterprise to become a paying one. It must not for a moment be supposed that we have one word to say against the expenditure of public money on such a work as the London-Paris telephone line; on the contrary, with many others, we feel strongly that it would be far better if more were spent on similar works of peace and less on costly and ponderous engines of destruction. But we think it right that it should be known that there is a limit beyond which such enterprises cannot be expected to pay for themselves.

REVIEWS.

The Art of Electrolytic Separation of Metals, &c. By G. GORE, LL.D., F.R.S., *The Electrician* Printing and Publishing Company.

The Electro-plater's Handbook; A Practical Manual for Amateurs and Young Students in Electro-Metallurgy. By G. E. BONNEY. Whittaker & Co., London.

These two works treat of two distinct branches of the art of electro-metallurgy taken in its widest sense. They also differ in their method of treatment; the former aiming at giving the most complete and most recent information on the subject with which it deals, while the latter is intended to supply elementary and simple lessons to amateurs and young students in an interesting and useful art.

Dr. Gore claims that his work is the first in any language "entirely devoted to the electrolytic separation and refining of metals." The information on this subject has hitherto been available only in scattered articles in periodicals and books, and the author deserves the thanks of those interested in this industry for having supplied this information in a systematic and handy form. The electrolytic separation of metals, though it promises much, appears as yet to have had little commercial success except in the separation and refining of copper. The processes described for the extraction of metals from their ores ought to be of great interest to manufacturers and inventors, as showing the success already attained, and the nature of the difficulties to be overcome. Processes are described for extracting copper, antimony, tin, aluminium, zinc, and other metals from their ores, among which may be mentioned Marchese's process for extracting copper from cupreous sulphide, Kleiner's process of separating aluminium from cryolite, Heroult's process for separating aluminium from alumina, and Letrange's process for separating zinc from blende. In all these processes the cost of the power necessary to produce the electric current appears to be prohibitive.

In another section of the work, the electrolytic refining of copper is treated in considerable detail; in fact, we feel that we have enough information given here to start a copper refinery. The arrangement and size of works for any required output is discussed; excellent blocks with short descriptions of the construction and specification of the power of the dynamos in use for copper refining are given. One point which is specially worthy of note is the wide variation in the weight of copper deposited per hour by 1 horse-power, under different conditions. According to data given, 1 horse-power is expended in different refineries in depositing quantities varying from 1·22 to 7·63 lbs. of copper per hour. This variation appears to be explained by some experiments of M. Gramme, given at p. 151. By placing a number of depositing baths in series, but extending the surfaces of the electrodes so that the resistance and current was kept constant, however much the number in series was increased, it was found that the total quantity of copper deposited was directly proportional to the number of baths. From this it may be inferred that the weight of copper deposited per hour by 1 horse-power may be increased indefinitely by increasing the number and size of the baths. A commercial limit, of course, will be reached when the increased cost in interest on the plant exceeds the economy in motive power.

Thus far we have reviewed the practical division of Dr. Gore's work. This is preceded by a theoretical division, which, in part at least, we cannot commend as being up to the same high standard. An excellent chapter (written by Mr. Guy C. Fricker) is given on the principles underlying the construction and action of dynamos; other two chapters give a very complete account of the chief facts of chemico-electric and electro-chemical action, and three chapters are devoted to an explanation of the electric, thermal and chemical facts and principles of the subject.

Few things are more important to the student of electricity than exact definitions of such terms as energy and work, and the great variety of electrical units now in continual use. But on this point the electro-chemists appear to be especially weak. Here are a few examples which disfigure Dr. Gore's otherwise excellent treatise. At p. 9 energy is defined "as motion;" "work done is resistance overcome, and is often attended by transformation of energy." At p. 12 the unit of capacity is defined as the capacity of a sphere of 1 centimetre radius, without mentioning the essential circumstance that the sphere must be at an infinite distance from all other conductors. At p. 14, "difference of electromotive force is considered to be due to difference of potential;" difference of potential *is* electromotive force, so that difference of electromotive force would be difference of difference of potential, whatever that may mean. At p. 23, "The practical unit of electric energy is termed a watt. . . . It is = 10^7 ergs; also ·7375 foot-pound. . . ." And, to conclude our list, at p. 80 it is stated that "the current from the anode spreads out in curves of *equipotential* lines."

The "Electro-platers' Handbook" is a clearly written little treatise on the electro-deposition of the ordinary metals dealt with by the electro-plater. An amateur could not wish for a better exposition of the elements of the subject. Mr. Bonney is evidently thoroughly acquainted with his subject, and gives neither too much nor too little detail in treating of the various processes and apparatus which practice has shown will produce the best results. If we were to specify any part of the work which is not quite up to the average level, it is the chapter on Dynamo-electric plating machines. To understand the principles of dynamo design does not appear to us to be essential to the electro-plater, and it is an open question whether such statements as this at page 66 will assist him much: "Each yard of active wire on an armature is capable of developing one volt when driven at an angular velocity of 1,250 feet per minute." Now angular velocity is usually measured not by feet per minute, but by number of turns per minute; Mr. Bonney makes it clear that what he means by angular velocity is the circumferential linear velocity of the armatrue wire, but it is to be regretted that he should use this term in an unauthodox sense. The work has an excellent index and 61 illustrations, and will form a useful addition to Messrs. Whittaker's valuable series of practical manuals.

EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.*

By NIKOLA TESLA.

In the *Electrical Engineer* issue of 11th inst., I find a note of Prof. Elihu Thomson relating to some of my experiments with alternating currents of very high frequency.

Prof. Thomson calls the attention of your readers to the interesting fact that he has performed some experiments in the same line. I was not quite unprepared to hear this, as a letter from him has appeared in the *Electrician* a few months ago, in which he mentions a small alternate current machine which was capable of giving, I believe, 5,000 alternations per second, from which letter it likewise appears that his investigations on that subject are of a more recent date.

Prof. Thomson describes an experiment with a bulb enclosing a carbon filament which was brought to incandescence by the bombardment of the molecules of the residual gas when the bulb was immersed in water "rendered slightly conducting by salt dissolved therein," (?) and a potential of 1,000 volts alternating 5,000 times a second applied to the carbon strip. Similar experiments have, of course, been performed by many experimenters, the only distinctive feature in Prof. Thomson's experiment being the comparatively high rate of alternation. These experiments can also be performed with a steady difference of potential between the water and the carbon strip, in which case, of course, conduction through the glass takes place, the difference of potential required being in proportion to the thickness of the glass. With 5,000 alternations per second, conduction still takes place, but the condenser effect is preponderating. It goes, of course, without saying that the heating of the glass in such a case is principally due to the bombardment of the molecules, partly also to leakage or conduction, but it is an undeniable fact that the glass may also be heated merely by the molecular displacement. The interesting feature in my experiments was that a lamp would light up when brought near to an induction coil, and that it could be held in the hand and the filament brought to incandescence.

Experiments of the kind described I have followed up for a long time with some practical objects in view. In connection with the experiment described by Prof. Thomson, it may be of interest to mention a very pretty phenomenon which may be observed with an incandescent lamp. If a lamp be immersed in water as far as practicable and the filament and the vessel connected to the terminals of an induction coil operated from a machine such as I have used in my experiments, one may see the dull red filament surrounded by a very luminous globe around which there is a less luminous space. The effect is probably due to reflection, as the globe is sharply defined, but may also be due to a "dark space;" at any rate, it is so pretty that it must be seen to be appreciated.

Prof. Thomson has misunderstood my statement about the limit of audition. I was perfectly well aware of the fact that opinions differ widely on this point. Nor was I surprised to find that arcs of about 10,000 impulses per second, emit a sound. My statement "the *curious* point is," &c., was only made in deference to an opinion expressed by Sir William Thomson. There was absolutely no stress laid on the precise number. The popular belief was that something like 10,000 to 20,000 per second, or 20,000 to 40,000, at the utmost was the limit. For my argument this was immaterial. I contended that sounds of an incomparably greater number—that is, many times even the highest number could be heard if they could be produced with sufficient power. My statement was only speculative, but I have devised means which I think may allow me to learn something definite on that point. I have not the least doubt that it is simply a question of power. A very short arc may be silent with 10,000 per second, but just as soon as it is lengthened it begins to emit a sound. The vibrations are the same in number, but more powerful.

Prof. Thomson states that I am taking as the limit of "audition, sounds from 5,000 to 10,000 complete waves per second." There is nothing in my statements from which the above could be inferred, but Prof. Thomson has perhaps not thought that there are two sound vibrations for each complete current wave, the former being independent of the direction of the current.

I am glad to learn that Prof. Thomson agrees with me as to the causes of the persistence of the arc. Theoretical considerations considerable time since have led me to the belief that arcs produced by currents of such high frequency would possess this and other desirable features. One of my objects in this direction has been to produce a practicable small arc. With these currents, for many reasons, much smaller arcs are practicable.

The interpretation by Prof. Thomson of my statements about the arc system leads me *now*, he will pardon me for saying so, to believe that what is most essential to the success of an arc system is a good management. Nevertheless I feel confident of the correctness of the views expressed. The conditions in practice are so manifold that it is impossible for any type of machine to prove best in all the different conditions.

In one case, where the circuit is many miles long, it is desirable to employ the most efficient machine with the least internal resistance; in another case such a machine would not be the best to employ. It will certainly be admitted that a machine of any type must have a greater resistance if intended to operate arc lights than if it is designed to supply incandescent lamps in series. When arc lights are operated and the resistance is small, the lamps are unsteady, unless a type of lamp is employed in which the carbons are separated by a mechanism which has no further influence upon the feed, the feeding being effected by an independent mechanism; but even in this case the resistance must be considerably greater to allow a quiet working of the lamps. Now, if the machine be such as to yield a steady current, there is no way of attaining the desired result except by putting the required resistance somewhere either inside or outside of the machine. The latter is hardly practicable, for the customer may stand a hot machine, but he looks with suspicion upon a hot resistance box. A good automatic regulator, of course, improves the machine, and allows us to reduce the external resistance to some extent, but not as far as would be desirable. Now, since resistance is loss, we can advantageously replace resistance in the machine by an equivalent impedence. But to produce a great impedence with small ohmic resistance, it is necessary to have self-induction and variation of current, and the greater the self-induction and the rate of change of the current, the greater the impedence may be made, while the ohmic resistance may be very small. It may also be remarked that the impedence of the circuit external to the machine is likewise increased. As regards the increase in ohmic resistance in consequence of the variation of the current, the same is, in the commercial machines now in use, very small. Clearly, then, a great advantage is gained by providing self-induction in the machine circuit and undulating the current, for it is possible to replace a machine which has a resistance of, say, 16 ohms by one which has no more than 2 or 3 ohms, and the lights will work even steadier. It seems to me, therefore, that my saying that self-induction is essential to the commercial success of an arc system is justified. What is still more important, such a machine will cost considerably less. But to realise fully the benefits, it is preferable to employ an alternate current machine, as in this case a greater rate of change in the current is obtainable. Just what the ratio of resistance to impedence is in the Brush and Thomson machines is nowhere stated, but I think that it is smaller in the Brush machine, judging from its construction.

As regards the better working of clutch lamps with undulating currents, there is, according to my experience, not the least doubt about it. I have proved it on a variety of lamps to the complete satisfaction not only of myself, but of many others. To see the improvement in the feed due to the jar of the clutch at its best, it is desirable to employ a lamp in which an independent clutch mechanism effects the feed, and the release of the rod is independent of the up and down movement. In such a lamp the clutch has a small inertia, and is very sensitive to vibration, whereas, if the feed is effected by the up and down movement of the lever carrying the rod, the inertia of the system is so great that it is not affected as much by vibration, especially if, as in many cases, a dash pot is employed. During the year 1885 I perfected such a lamp which was calculated to be operated with

* *Electrical Engineer.*

undulating currents. With about 1,500 to 1,800 current impulses per minute the feed of this lamp is such that absolutely no movement of the rod can be observed, even if the arc be magnified fifty-fold by means of a lens; whereas, if a steady current is employed, the lamp feeds by small steps. I have, however, demonstrated this feature on other types of lamps, among them being a derived circuit lamp such as Prof. Thomson refers to. I conceived the idea of such a lamp early in 1884, and when my first company was started, this was the first lamp I perfected. It was not until the lamp was ready for manufacture that, on receiving copies of applications from the Patent Office, I learned for the first time, not having had any knowledge of the state of the art in America, that Prof. Thomson had anticipated me, and had obtained many patents on this principle, which, of course, greatly disappointed and embarrassed me at that time. I observed the improvement of the feed with undulating currents on that lamp, but I recognised the advantage of providing a light and independent clutch unhampered in its movements. Circumstances did not allow me to carry out at that time some designs of machines I had in mind, and with the existing machines the lamp has worked at a great disadvantage. I cannot agree with Prof. Thomson that small vibrations would benefit a clockwork lamp as much as a clutch lamp; in fact, I think that they do not at all benefit a clockwork lamp.

It would be interesting to learn the opinion of Mr. Charles F. Brush on these points.

Prof. Thomson states that he has run with perfect success clutch lamps "in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out." Surely Prof. Thomson does not mean to say that self-induction wiped out the periodical fluctuations of the current. For this, just the opposite quality—namely, capacity, is required. The self-induction of the coils in this case simply augmented the impedence and prevented the great variations occurring at large time intervals, which take place when the resistance in circuit with the lamps is too small, or even with larger resistance in circuit when the dash pots either in the lamps or elsewhere are too loose.

Prof. Thomson further states that in a lamp in which the feed mechanism is under the control of the derived circuit magnet only, the fluctuations pass through the arc without affecting the magnet to a perceptible degree. It is true that the variations of the resistance of the arc, in consequence of the variations in the current strength, are such as to dampen the fluctuation. Nevertheless, the periodical fluctuations are transmitted through the derived circuit, as one may convince himself easily of, by holding a thin plate of iron against the magnet.

In regard to the physiological effects of the currents, I may state that upon reading the memorable lecture of Sir William Thomson, in which he advanced his views on the propagation of the alternate currents through conductors, it instantly occurred to me that currents of high frequencies would be less injurious. I have been looking for a proof that the mode of distribution through the body is the cause of the smaller physiological effects. At times I have thought to have been able to locate the pain in the outer portions of the body, but it is very uncertain. It is most certain, however, that the feeling with currents of very high frequencies is somewhat different from that with low frequencies. I have also noted the enormous importance of of one being prepared for the shock or not. If one is prepared, the effect upon the nerves is not nearly as great as when unprepared. With alternations as high as 10,000 per second and upwards, one feels but little pain in the central portion of the body. A remarkable feature of such currents of high tension is that one receives a burn instantly he touches the wire, but beyond that the pain is hardly noticeable.

But since the potential difference across the body by a given current through it is very small, the effects can not be very well ascribed to the surface distribution of the current, and the excessively low resistance of the body to such rapidly varying currents speak rather for a condenser action.

In regard to the suggestion of Dr. Tatum, which Prof. Thomson mentions in another article in the same issue, I would state that I have constructed machines up to 480 poles, from which it is possible to obtain about 30,000 alternations per second, and perhaps more. I have also designed types of machines in which the field would revolve in an opposite direction to the armature, by which means it would be possible to obtain from a similar machine 60,000 alternations per second, or more.

I highly value the appreciation of Prof. Thomson of my work, but I must confess that in his conclusion he makes a most astounding statement as to the motives of his critical remarks. I have never for a moment thought that his remarks would be dictated by anything but friendly motives. Often we are forced in daily life to represent opposing interests or opinions, but surely in the higher aims the feelings of friendship and mutual consideration should not be affected by such things as these.

THE HAMPSTEAD VESTRY AND THE ELECTRIC LIGHT.

THE Easter Vestry in Hampstead was held on Tuesday evening, Major-General YOUNG presiding, when the report of the specially appointed Electric Lighting Committee was presented and discussed.

The report stated that the committee h d had the opportunity of conferring with Mr. W. H. Preece, F.R.S., and of fully considering his report on the subject of electric lighting in Hampstead. Mr. Preece recommended the vestry itself to undertake the installation of electric lighting, both for street illumination and for the supply of private houses, shops, public buildings, &c., at an estimated capital outlay of £81,000. This sum provided for the ultimate lighting of the whole area of the parish, but Mr. Preece would not expect it to be necessary or even possible to spend the whole sum in one year. It would probably not be fully spent for a period of four years. The attention of the committee had been first directed to the question whether, in the event of their recommending Mr. Preece's plan for adoption, it would be advisable to separate the cost of installing a system of public lighting, viz., £15,000, from the cost of the proposed system of private lighting, viz., £66,000. It appeared, however, that the cost of public lighting would be so moderate as £15,000 only if it were taken in connection with the outlay for private lighting. On this point the committee was emphatically of opinion that no such separation should be attempted, but that the two systems of lighting the public streets and lighting private buildings should decidedly be taken together, but the scheme was such that if the vestry desired to contemplate a restricted outlay a good result could be procured for £20,000 or £25,000. The difference between a restricted outlay and an outlay which would be part of the whole £81,000 was this—that under a restricted outlay the vestry would contemplate the lighting of certain parts of the parish, and no more; whereas, under the full scheme, the intention would be to cover the parish. In the former case it would be necessary, by some test which the vestry should decide on, to determine which parts of the parish should be lighted at all. It would not be impossible to devise this test, but probably any arbitrary selection of areas would be unpopular and open to criticism, and the committee do not advise the adoption of that course. The committee was of opinion that the justification of the vestry for accepting the proposal now before it would lie in its ability and settled intention to do the work of lighting more thoroughly, more completely, and more economically than it would be done by any private company. The main question was that of profit or loss. Mr. Preece estimated that from the private and public lighting an annual revenue will be derived, when the system was in full working order, of £19,500, collected at working charges of £15,800 a year. It was right to explain that in Mr. Preece's estimate of revenue he included £1,400, the increased cost of electric light over gas for public lighting; for which extra outlay about three times the amount of light will be obtained. Even deducting this item there would still remain a profit of £2,300 available towards payment of interest and repayment of capital. The balance of gross profit, viz., £3,700, he showed would be equal to 4·6 per cent. on the capital proposed to be expended. The sum required to repay a loan at 3½ per cent. in 30 years by an equal annual payment of principal and interest combined was £5 8s. 9d. per cent., or on the whole expenditure of £81,000, a sum of £4,405 a year. On money borrowed for fifty years the equal annual payment would be £4 5s. 3¼d., equal to a total annual payment of £3,455. Mr. Preece estimated that electrical energy could be supplied to consumers at 6d. per Board of Trade unit; the lowest charge of any private company in the metropolitan district, he stated, was 7¼d. per Board of Trade unit; and in some cases the charge was 8d. Here, then, was a minimum saving of 17 per cent. to the consumer, comparing companies' prices with the proposed vestry prices. The average cost per lamp per annum to the consumer, Mr. Preece stated, would be 12s. 6d., including repairs and renewals. The probabilities were that ultimately, about 24,000 electric lamps, each of 16-candle power, will be rented by the ratepayers. The cost of "wiring" and fitting up he puts at 25s. per lamp, or for, say, 20 lamps, £25, and the total charge for light, at 12s. 6d. for each of the 20 lamps (this charge of course being subject to the results of measurement by meter), £12 10s. per annum. There could be little doubt that the bulk of the houses yet to be built in Hampstead would be "wired" during construction, and that the owners or leaseholders of most of the houses of good rental, say of over £100 a year, would probably incur the expense of equipment; but the doubt in the mind of the committee was the extent to which tenants of houses held under agreements for three years, or on leases for short terms at

lower annual rentals than £100, would be inclined to bear the necessary cost of "wiring" and fittings. This seemed to be a matter for the individual judgment of each vestryman. The impression of the committee was that even under a three years' agreement, the tenant of perhaps a £50 house might be inclined to spend a small sum for a small equipment. From these points of view, Mr. Preece's estimate of 1,200 houses taking the light out of a total 9,000 houses in the parish did not seem unreasonable. The average of 20 lights per house, assumed by Mr. Preece, was arrived at by him on the ascertained results of gas lighting. Now, the present cost of illuminants was probably not less than £10 or £12 a year; and such amount was swelled by gas fitters' bills, by the cost of recolouring ceilings, repapering, and sundry other expenses all but too well known to householders. Probably £15 a year would not be an unfair estimate of the present actual cost of lighting an £80 house. Against this amount were to be set in the case of electric lighting:—The cost of fitting up 20 lamps at 25s. each, £25; the annual cost of 20 lamps at 12s. 6d. each, £12 10s. On these figures there did not seem to be any material difference in cost between the two methods of illumination; the superiority of the glow lamp, however, over gas, in brilliancy and steadiness of light, in convenience of turning "off" and "on," in health, as regarded purity of the atmosphere of a living room and freedom from impurities and discolouration of wall surfaces, book bindings, gilt frames, and the like, was incontestable. A table of the rateable values of houses in 1886 was here inserted, and also an estimate furnished by Mr. Preece of the cost of wiring, as follows:—

	No. of houses.
Houses rated at and under £30	1,671
„ £31 to £50	2,079
„ £51 to £100...	2,920
„ over £100	1,211
Total ...	7,881

Estimate of the Cost of "Wiring" Houses of Various Rentals, with the Probable Annual Cost of Current.

Rental value.	No. of lamps.	Cost of Wiring.	Annual cost of light.
		£ s. d.	£ s. d.
£40 per annum ...	10	12 10 0	6 5 0
£50 „	12	15 0 0	7 10 0
£60 „	16	20 0 0	10 0 0
£70 „	20	25 0 0	12 10 0
£80 „	24	30 0 0	15 0 0
£100 „	36	45 0 0	22 10 0
£150 „	50	62 10 0	31 5 0

Of course, in all new undertakings a certain financial risk had to be encountered. But other things being equal, it is evident that there would be this solid advantage in the means of electric lighting being in the hands of the borough, that the vestry could at all times adopt and profit by the increase of scientific information, and the ratepayer would always have the means of procuring the redress of a grievance, and of insisting on efficiency of management. On the whole, therefore, the committee forms the opinion that it was desirable that the electric light should be introduced into Hampstead, and that the necessary steps should be taken by the vestry for procuring a provisional order, and for giving effect to Mr. Preece's recommendations.

Mr. Baines, chairman of the committee, was prevented by a severe cold from being present, but sent a communication, which was read, to the effect that the matter should be considered from the points of view of the consumer and of the ratepayers. As the vestry did charge 6d. per unit as against a probable 7½d., there would be a saving to the estimated number of consumers of £2,520 per year, the aggregate charge for private lighting being £15,120. The parish would pay £6,900 a year for lighting the street, which was estimated at the cost price of 4d. per unit, and would provide three times the present light. The saving effected by doing the work itself would be £6,881 a year. In answer to the ratepayers' question, they must set down on the debit side as the rental from private lighting £12,600 a year, and £5,500 a year as the cost of gas no longer consumed in lighting the streets, together £18,100. On the credit side there would be the cost of production of private light £8,900, and public lighting, allowing three times the present light from sunset to midnight, and 50 per cent. more than the present light to sunrise, £4,830, giving the total cost of production as £13,730, which would leave an available balance of £4,370 to meet the £4,405 required to pay interest and to repay the loan of £81,000 in 30 years. The answer to the ratepayers' question would, therefore, be: "You gain the advantage of a three-fold light from sunset to midnight, and a 50 per cent. increase afterwards, coupled with a saving to the parish of £6,960 a year as compared with a company's charge, at a net annual cost to the parish of the trifling sum of £35 a year.

After some discussion the report was received, and the final decision postponed to May 7th, Mr. Maurice giving notice that when the matter next came on for discussion he would move that in the event of there being a deficit on the year's working the repayment of it should be confined to those persons who were rated at over £80 a year.

A letter was read from the Tottenham Company, which is seeking powers to include Hampstead within its operations, offering the vestry special terms if it would not oppose the application of the company to the Board of Trade.

Dr. Alford was permitted to move, as a matter of urgency, that a poll of the ratepayers should be taken, but his motion was lost by a large majority.

THE ST. PANCRAS ELECTRICAL EXHIBITION.

(*Concluded from page* 411.)

Benham & Froud.

This firm exhibited electroliers in copper, brass, silver-plated, and in mixtures of these metals, very light in character, abundant in wrought metal leaves, and flowers and scrolls, altogether unlike gas fittings, usually fitted with effective coloured and cut glasses,

some being wired in series with imitation candles and silk shades. They had also brackets in the same styles, as well as in bold wrought iron work with curious art glass introductions. Some girondoles in bronze, brass and glass, and some floor lamps with elabo-

rate silk shades, were handsome specimens; and a specially striking object amongst the table pillars with shades was a reproduction of some of those used at the Hotel Metropole, Brighton, for which building the firm supplied 500.

Richard Frères.

Amongst the exhibits in the engine room were to be seen in use a Richard Frères's self-recording, 500-ampère ammeter and one of their voltmeters. There was also a steam pressure gauge of their make, but this was not at work, as it is only graduated to 120 lbs., whereas Messrs. Sharp and Kent's boiler worked at 140 lbs. pressure.

On Wednesday evening the Electrical Exhibition, opened in St. Pancras Vestry Hall three weeks ago, was brought to a conclusion, having throughout been most successful; in fact, so much so, that the

original period was extended by eight days. At the close of the exhibition the exhibitors, some friends, and the Electric Lighting Committee of St. Pancras Vestry, dined together in the Midland Grand Hotel. Mr. Churchwarden Boden presided, and was supported by Alderman Gibb, Prof. Robinson, Messrs. W. T. Wetenhall, L.C.C.; J. H. William, L.C.C., &c. The usual loyal toasts having been honoured, Mr. R. W. Wallace proposed the toast of "The St. Pancras Vestry," and in the course of his remarks bore testimony to the able manner in which they had entered into the scheme of lighting South Pancras with electricity. He believed it would prove successful and be of the greatest advantage to those who wished to carry on industries in their own houses. Mr. Wetenhall responded, and agreed with Mr. Wallace that electricity would prove the light of the future, and also that the vestry were justified in adopting the course they had in introducing the system. Prof. Robinson also spoke, and expressed the pleasure he felt that the exhibition had been so thoroughly successful. It had been very largely attended, and considerable interest had been evinced in the proceedings throughout. He referred briefly to the scheme, and concurred thoroughly with the remarks of Mr. Wallace as to the use which electricity would be put to. Other toasts followed, and the proceedings then terminated.

ELMORE'S LATEST.

THE proposal to form a trust to take up the vendor shares in the Continental Elmore Companies appears to have given place to a scheme almost as ingenious. That is to palm off those shares on the individual shareholders of the foreign parent company. Thanks to the successful flotation of the French and Austro-Hungarian companies, the directors have been able to pay £5 to each holder of a priority share, leaving £5 to be distributed ere the founders can get anything at all. Under the articles of association the Foreign and Colonial Company can only distribute profits actually realised and converted into cash. The £5 paid to the priority holders represents the cash portion of the purchase money and the premiums on the issue price of the shares of the two subsidiary companies. It is now proposed that the unrealisable shares of these concerns which completed the purchase price should be distributed to the priority shareholders "at their par value," in fulfilment of the promises of the prospectus. Yet the priority shareholders are invited to take over, as worth £2 apiece, these depreciated shares in lieu of hard cash.

One may ask with a good deal of reason how it happens that the cash payments received from the subsidiary companies have gone such a short distance towards realising the prospectus promise, that the priority shareholders should get £10 apiece in money. The two promotions should have yielded a gross cash return of £204,375, if the shares were all subscribed. Of course there must have been heavy preliminary expenses, for the Elmore promotions have to provide the greater part of the dividends for Woodhouse and Rawson United, Limited, and the Elmores are judiciously generous with their new company advertisements. Still it is odd that though the French company alone—the promotion of which, we know from the chairman, was a brilliant success—must have given the Foreign and Colonial concern £116,000 in cash, the money distribution has only been £75,000 up to the present. It would seem, then, that even when subsidiary companies are floated on such terms that they have to begin borrowing on debentures before they can get to work, the promotion of little Elmores is not, after all, such a very paying business as the priority shareholders of the Foreign and Colonial Company were led to expect.

We should strongly recommend the priority shareholders to reject this precious proposal for palming off on them depreciated shares as the equivalent of hard cash. In September last Woodhouse and Rawson United, Limited, was good enough to send out a circular which foreshadowed the promotion of an American and a polyglot (Belgian-Italian-Spanish-Portuguese-Swiss) company, each of which was to pay £38,500 in cash for the Elmore patents, besides shares. There were the possibilities in these of another £5 distribution to the priority shareholders. We do not see much likelihood of the appearance of more little Elmores, but the probability that the French and Austro-Hungarian shares will reach par is quite as remote. So that of two evils we should recommend the priority shareholders to choose the least, which seems to be to retain their right to cash returns, even if they cannot get the money so quickly as they anticipated.—*Financial Times.*

ALTERNATE CURRENT CONDENSERS.*

By J. SWINBURNE.

THOUGH condensers have been proposed for various methods of distribution of electrical power, schemes involving the use of them have never developed enough for alternating current condensers to be made commercially. It is generally assumed that there is no difficulty in making them; all that is needed is to separate a number of thin plates by means of sheets of insulating material.

The first difficulty is insulation. If a condenser is to take 2,000 effective volts, the insulation must be very good. Too great thickness of dielectric cannot be allowed, as that would lessen the capacity, and increase the cost of material. The surface of such a condenser for, say, 10 ampères is about a 1,000 square feet, and the problem of making a 1,000 square feet of thin insulating material that will safely stand 2,000 volts is not easy. I have made samples which, though only a little over a tenth of a millimetre thick, would stand 8,000 effective volts for some time before breaking down. When made up into a large condenser, 2,000 or 3,000 volts would generally break it down in a few hours.

Insulation is not by any means the only difficulty, however; there is another, which is probably intimately connected with it, and that is absorption of electric power in the dielectric, and consequent heating. It is well known that Leyden jars get hot if charged and discharged frequently; and also that the phenomenon of electric absorption is manifested. When there is absorption, the current out of the condenser is not proportional to the rate of decrease of the electromotive force, and probably the current into it is not proportional to the rate of increase. This means that the condenser absorbs energy and converts it into heat.

Such questions have been frequently studied in connection with curves of sines, but it is easier to show the truth of this generally. Let C be the current, E the electromotive force, K the capacity, and t the time. Then

$$C = K \frac{dE}{dt},$$

and the power spent at any instant,

$$EC = EK \frac{dE}{dt}.$$

If e is the maximum electromotive force, the work done in charging the condenser is thus

$$K \int_0^e E\,dE = \tfrac{1}{2} K e^2,$$

the ordinary expression. On discharging, the work absorbed is

$$K \int_e^0 E\,dE \text{ or } -\tfrac{1}{2} K e^2.$$

It is equally easy to show that no power is absorbed in the case of an induction coil with no hysteresis, without assuming the pressure to vary harmonically.

If C does not vary as the rate of increase or decrease of E, but is greater on charging and less on discharging, power is absorbed. A hysteresis curve, like those we are accustomed to in iron, can be plotted in the case of a condenser. It has no very close analogy with the case of iron, however.

At first it might seem that absorption might be neglected as too trifling to matter in commercial work. This, however, is not the case. Some condensers about a foot square and an inch thick absorbed over half a horse-power, and soon rose above the temperature of boiling water.

According to Maxwell's theory, the absorption of power is just as easily explained as the time lag in discharge. Suppose the dielectric is paper soaked in melted paraffin, and suppose the fibres of paper do not insulate and that the paraffin does. When the plates are charged, a fibre running part of the way across the dielectric finds its ends at different potentials; so a current is set up to equalise them. This current means loss of power by heat. It also increases the capacity of the condenser. An increase of the capacity of the condenser when the pressure is increasing, or after it is applied, means increased energy put into the condenser. If the capacity of the condenser were constant, the current into it would be proportional to the rate of increase of the electromotive force, and no power would be absorbed in a period; but if the capacity is increased as the pressure rises and decreased as it falls, there is an extra current produced which is not proportional to the rate of increase of the electromotive force, and this supplies the loss in the condenser. The condenser may still show perfect insulation under a direct pressure. According to this theory, absorption is necessarily accompanied by an increase of capacity. This is important in connection with the electro-magnetic theory of light. Absorption would always increase the apparent capacity of a condenser, so that determinations of specific inductive capacity of absorptive dielectrics would come out too high. The dielectrics which come out too high, such as glass, are just those which heat most. The energy absorbed in a given dielectric would be a function of the frequency and the resistance of the conducting parts. It is thus possible that a dielectric might be opaque to light, and diathermanous if the resistance is comparatively low, or transparent to light, but not to dark heat if it is somewhat higher. Similarly a Leyden jar, which absorbs power when connected to an alternating dynamo, may lose little of its energy internally when discharged oscillatorily by a spark. The case of a fibrous imperfect insulator embedded in a perfect insulator is not susceptible of mathematical treatment and was not taken by Maxwell. Mica is perhaps a better example. It is a good insulator, but gets very hot. If a thin plate is put between two sheets of tin foil, heating soon shows. Here we have tinfoil, then a stratum of air, then mica, which is itself stratified, then air, then tinfoil again. The static attraction presses the foil close against the mica, still there is air, Unless the mica is very thick, the fall of potential between the plates is so rapid that the air breaks down and there is a disruptive discharge between the foil and the mica. This actually occurs; there appears to be a luminous layer of minute blue sparks under the foils, and there is a strong smell of ozone. The discharge under the foils, which is rendered visible by the transparency of the mica, must not be confused with the brush-discharge round the edges of the foil, which differs in appearance. There is considerable heating even when the foil is affixed with paraffin wax so that there is no air.

Of course mica, being stratified, may consist of alternate sheets of some imperfect conductor and an insulator. It is more difficult to find a reason why glass should heat. At high temperatures it is an electrolyte, and it has no definite solidifying-point, so it may be

* Read before the Physical Society on December 12th, 1890.

partially electrolytic at ordinary temperatures. Such an explanation can hardly be applied to such a substance as celluloid. This is a very perfect insulator, at least till it breaks down disruptively, and it seems to be homogeneous, and is not hygroscopic, yet it heats considerably.

For commercial condensers the choice of insulating material is limited. Most work has been done on condensers with paper and hydrocarbon insulation. It is difficult to know whether a fault lies in the paper or in the hydrocarbon. The paper is baked at a high temperature, and all temperatures and times of baking have been tried. Paper goes on giving off water till there is nothing but a charred brittle mass left. Many hydrocarbons contain enough water to prevent, for instance, their dissolving rubber. Phosphoric anhydride was used to dry several samples, but seemed to do little good, in fact the crude hydrocarbon was often better. Papers vary astonishingly in their behaviour. Mr. Bourne, who has been working at these things for some months, has tried almost every conceivable way of making condensers. We are just beginning to succeed, but it is more by chance than anything else. We see no reason why one particular kind of paper and one particular kind of hydrocarbon should be better than the others.

Want of homogeneity in the dielectric of a condenser, or of any cable, may lead to disruptive discharges, or breakdowns. For instance, if a dielectric is made up of portions with inductive capacities of 3 and 1 respectively, the parts with a high inductive capacity may arrange themselves so that the "electric displacement" in the other is so great that a disruptive discharge ensues. For instance, if two conducting plates are 3 millim. apart in air, with enough pressure to spark over 2 millim., and if a 2 millim. slab of a dielectric with a specific inductive capacity of 3 is put in, the fall of potential over the air is nearly doubled, and it breaks down and starts a short circuit.

Loss of power in dielectrics is not confined to condensers; it may be very serious in cables. A condenser that heated excessively was made like the Deptford mains. The dielectric was very much thinner in proportion to the pressure, and allowing the loss per cubic centimetre to vary as the square of the pressure on its sides, a Deptford main would have a loss of, very roughly, 7,000 watts in the dielectric.

It does not follow that this is the exact loss in a Deptford main. Very small differences in the constitution of the dielectric cause large variations in the power wasted. The loss may therefore be very much greater or very much less. Taking the specific inductive capacity of the dielectric as 2, a seven-mile main has a capacity of 2 microfarads. With 10,000 volts at a frequency of 80, this takes 10 ampères and 100,000 "apparent" watts; 7,000 watts is only a small percentage of this.

Another unexpected effect has occurred at Deptford. There is an extraordinary rise of pressure. No authoritatively accurate accounts have been published, so it is difficult to say what has happened; but it is said that when the mains are put on the pressure rises. This is generally explained by saying the mains have capacity, and there is self-induction in the circuit, and the capacity and self-induction have a period which corresponds with the frequency of the dynamo, so that the system sympathises, or acts as a sort of electric resonator, thus giving abnormally high pressure. A little consideration will show that this theory is untenable. With such a capacity as that of the Deptford cables the self-induction would have to be enormous.

Let the capacity of the cable be K, and the self-induction of the circuit L, in farads and henries or quadrants. Call E and C the electromotive force and current respectively. Then

$$E = L \frac{dC}{dt}$$

and

$$C = -K \frac{dE}{dt}.$$

Combining these equations,

$$\frac{d^2E}{dt^2} = -\frac{E}{KL};$$

so

$$\frac{dE}{dt}\frac{d^2E}{dt^2} = -\frac{E}{KL}\frac{dE}{dt};$$

and integrating,

$$\left(\frac{dE}{dt}\right)^2 = -\frac{1}{KL}(E^2 + a),$$

where a is a constant;

or

$$\frac{dE}{dt} = -\frac{1}{\sqrt{KL}}\sqrt{(E^2 + a)};$$

so

$$\frac{\sqrt{KL}\,dE}{\sqrt{E^2 + a}} = -dt,$$

and integrating,

$$\sqrt{KL}\cos^{-1}\frac{E}{a} = t,$$

therefore

$$E \propto \cos\frac{t}{\sqrt{KL}}$$

and

$$T = 2\pi\sqrt{KL}$$

When a charged condenser is short-circuited through a circuit with self-induction only, oscillation is produced, the current and pressure both varying harmonically with a frequency of $1/2\pi\sqrt{KL}$.

In the Deptford case, with a capacity of two microfarads and a period of 0·0125, the self-induction needed would be half a henry. A choking coil with such a coefficient of self-induction wound to carry 250 ampères, which, I understand, is the load of one main, would take 64,000 volts to get the current through. A transformer only acts on the circuit as a choking coil to the small extent due to the waste induction in it. If built on the lines of commercial transformers, this one would have to be large enough to give an output of hundreds of millions of watts to produce a resonator effect. Moreover, a slight alteration in the speed of the dynamo would throw it "out of tune" with the resonator, so that the effect would disappear. For instance, a 5 per cent. variation of speed would alter the pitch of the dynamo nearly a semitone.

It has been stated that there is a difference of apparent ratio in the Deptford transformer when the main is in circuit; that is to say, that though it generally transforms 4 to 1, when the main is on it transforms about 4½ or 5 to 1. I would suggest this is impossible. There is always a "drop" in transformers due to waste field. In a transformer for 10,000 volts and 250 ampères, if properly designed, it would be well under 1 per cent., probably about one tenth per cent. In order that an oscillatory current should be confined to the "line" side by the waste induction which causes a drop of 1 per cent. and 80 periods per second, the frequency would have to be enormous. Such an oscillatory current would also be excluded from the secondary at the London end. Any effect which does not involve enormous frequencies must show on both sides of the transformers. It might be said that the "drop" of the transformers in the circuit would give enough self-induction to produce a frequency corresponding to an upper partial of the note of the dynamo. If the dynamo E.M.F. does not vary harmonically, such an effect might be produced, but it would show on the voltmeters at both ends. To give an increase of 15 or 20 per cent. effective pressure, with a total transformer drop of 1 per cent., the frequency would be, roughly, 1,000, and the effective pressure of the oscillatory component 6,000 volts. This would give 72 ampères, and the "skin effect" would absorb a great deal of power.

There is, however, a simpler explanation. The cables have considerable capacity, and take an appreciable current. This "leads" relatively to the electromotive force, so the capacity current passes in the armature-coils when they are just in the position to magnetise the fields more strongly. The fields cannot follow each pulsation of excitation so produced, but are affected by it. Their average excitation is increased. I have tried putting a condenser on one of the old Gramme alternators, which have rather weak fields, and a large number of armature ampère turns. The pressure ran up and burned the voltmeter. I have already gone fully into the action of leading and lagging currents on dynamo fields elsewhere, so the subject need not be pursued here. It would, no doubt, be possible to make an alternator excite itself like a series machine by putting a condenser on the terminals instead of exciting the fields by a direct current machine. Such an arrangement seems scarcely commercial, though interesting.

THE ELECTRICAL CONDUCTIVITY OF PRECIPITATED "MEMBRANES."

The researches of W. Ostwald upon the electrical properties of semi-permeable walls, which were reported in our issue for January 9th, have been followed by an investigation by G. Tammann into the conductivity of precipitated "membranes," which has, however, led to even more interesting results.

When a solution of sulphate of copper is carefully poured upon the surface of a solution of ferrocyanide of potassium at the line of demarcation between the adjacent surfaces of these two liquids there forms an exceedingly fine membrane of ferrocyanide of copper; this "membrane" or film permits water to transfuse it, but prevents the transfusion of any of the salts which may be present in the solutions.

But although the "membrane" exercises the limiting action with regard to the passage of salts in solution, its presence in an electric circuit does not increase the resistance.

Tammann's method of investigation was as follows:—He prepared solutions of sulphate of copper and ferrocyanide of potassium which were such that their electrical conductivity was equal. These solutions were superposed in an electrolytic cell in such a way that one horizontal electrode was immersed in one solution, and the other electrode in the other. The current of electricity had thus to traverse the precipitated semi-permeable wall or "membrane," and on measuring the resistance it was found to be exactly the same as before.

A "membrane" of ferrocyanide of zinc behaves at first very much like a "membrane" of ferrocyanide of potassium, but after some time it increases in thickness, becomes opaque, and then begins to allow the salts in solution to permeate or transfuse. Meanwhile its electrical resistance grows greater, and in about 15 minutes attains a maximum.

Precipitated "membrane" of hydroxide of zinc and hydroxide of copper thickens rapidly also, and at the same time diminishes the electrical conductivity; this diminution is from 5 to 8 per cent.

In the case of membranes of insulating materials, such, for instance, as one of pyroxlin, the resistance to the flow of the current is enormously increased, and in such cases it appears that the only conduction which takes place is that through the minute pores of the membrane.

The original paper may be consulted in detail in the *Zeit. physikalishe Chemie*, vi., pp. 237—240.

NOTES.

Mr. Ferranti's Rival.—A Nürnberg firm advertises that it is prepared to deliver cable for high tension current up to 10,000 volts.

Electric Tramway in Marseilles.—MM. Sautter, Harlé et Cie, and the Oerlikon Engineering Works are about to equip a new tramline for the local tramway company, on the overhead system. This will be the second of its kind in France.

Electric Light for Coast Defence.—The military authorities have decided that the officers and men of the Royal Artillery are to be instructed in the manipulation of the electric light and machinery, and classes for this purpose have been opened at the School for Military Engineering, at Chatham. The first class is to be taken from the Garrison Artillery of Portsmouth, in order that they may be able, without delay, to work the electric light in the coast batteries of that fortress.

The Commercial Cable Company.—The *Canadian Gazette*, published in London, is informed by telegraph that at the annual meeting of the Commercial Cable Company on the 16th ult., Messrs. J. Gordon Bennett, A. B. Chandler, G. S. Coe, C. R. Hosmer, G. G. Howland, R. Irving, Jun., J. W. Mackay, J. W. Mackay, Jun., C. Platt, Thomas Skinner, Sir Donald A. Smith, Mr. W. C. Van Horn and Mr. George G. Ward were elected directors.

A Wonderful Contrivance.—Under the striking title of "Assymmetrical Electrical Resistance," we find described in the New York *Electrical Review*, a device invented by a Mr. Bottome for the purpose of directing alternating currents into currents of a continuous nature. The invention consists of an aluminium and a platinum, or carbon, plate immersed in a liquid (it is not stated what); this arrangement is inserted in the path of the alternating current and is stated to be "impervious to currents of one sign and permitting those of the opposite sign to pass." The contrivance is so ingenious that the journal publishing a description of it considers it to be worthy of an illustration, the latter showing two electrodes immersed in a jar of liquid. The responsible editor of the journal in question is, we presume, taking a holiday, leaving the office boy in full charge.

The Theatrophone.—There was founded last year at Paris, the "Theatrophone Company," the object of which is the institution of a telephonic theatrical service. The company has erected in the various public places, such as cafés, clubs, restaurants, &c., a certain number of automatic telephone receivers by which, on introducing a fifty centimes piece, one is placed in communication, for five minutes, with theatres or concerts indicated on the apparatus. At present the Opera Comique, the Bouffes, and the Nouveautés are the only theatres in connection with the system, but the number will be soon increased. The Theatrophone Company intends to supplement this public service by a private service, available for all subscribers to the State telephone system. By means of the monthly subscription of fifteen francs, and a payment of fifteen francs per evening for this service, a subscriber to the Paris system can enjoy telephonic communication with a given theatre, selected from among those connected with the service, during the entire performance, and for any number of listeners. The prices given above are for two receivers. The addition of extra telephones, so that several persons may hear at once, entails a further charge of two francs per pair per month.

The Cost of Cable Repairing.—There have been widely distributed in London and its neighbourhood circulars offering for sale £25,000 worth of 4½ per cent. first mortgage debenture bonds, forming part of the debenture capital, £120,000, of the Halifax and Bermudas Cable Company. Our attention has been called to a passage contained in these circulars which details the securities guaranteeing the repayment of principal and interest to the holders of the debentures, and which concludes with the following paragraph:—"The company having effected an insurance for an amount of £3,000, a sum considered amply against accident to the cable, the £15,000 of securities lodged with the Government will practically remain intact." Although it would seem that the word 'sufficient' has been omitted, or that 'ample' was intended instead of 'amply,' yet the meaning is clear enough, and it must be concluded that whoever made the above-mentioned estimate of the cost of a cable repair, could only have considered the possibility of the cable breaking, or proving faulty, in shallow water and on a good bottom; otherwise the calculated cost is ridiculously under-estimated. Even in the case of a shallow water repair, good weather must be a *sine quâ non* for the amount specified to be within the mark. It would be interesting to know upon what basis the estimate was drawn up, what sized ship was in view and the cost of hiring, the number of crew, cable hands, officers and engineers supposed to be adequate for the work, what the salaries, wages, and provisioning would come to, what would be the coal consumption, and what the expenditure of deck, engine room, and cable stores, and lastly, what allowance is made for old cable lost and new cable expended.

Tasmanian Exhibition.—This Exhibition, which will be opened at Launceston on the 14th October, 1891, will be carried out under the direct patronage and with the aid of the Governor and his Government. It is proposed to supply motive-power for machinery in motion free of charge. Applications for space should be made at the earliest possible date to the Honorary Secretary of the Tasmanian Exhibition, 5, Victoria Street, S.W., from whom all information can be obtained.

Royal Institution of Great Britain.—A course of four lectures on the dynamo will be given, by Professor Silvanus P. Thompson, on the following days, at 3 o'clock:—Lecture I., Saturday, April 11th, 1891. Development. Faraday's discovery of induction; the early magneto-electric machines; development of modern forms; modes of obtaining continuity of action; modes of excitation; improvements of Hjörth, Siemens, Holmes, Wilde, the Varleys, Wheatstone, Pacinotti, Gramme, Brush, Elihu Thomson, Edison, Hopkinson, Crompton, Mordey, Brown, and others. Lecture II., Saturday April 18th, 1891.—Principles. Design and construction of modern dynamos; distinction between various classes of dynamos; alternating currents and direct or continuous currents; constant pressure machines and constant current machines; the principle of the magnetic circuit; armature and field-magnet. Lecture III., Saturday, April 25th, 1891.—Details. Means for collecting the currents given out by the armature; commutators and brushes; why there is sparking at the brushes; causes of inefficiency, and their cure; the regulation of electric lighting machinery. Lecture IV., Saturday, May 2nd, 1891.—Adaptations. Alternate current machines; the improvements of Ferranti, Mordey, Kapp, and others; high-pressure dynamos. and their *raison d'être*; probable future of dynamo machinery. The following discourses are included in the probable arrangements for the Friday evening meetings after Easter, 1891;—Friday, April 10th, Sir William Thomson, D.C.L., LL.D., Pres. R.S., M.R.I., "Electric and Magnetic Screening;" Friday, April 17th, Professor A. W. Rücker, M.A., F.R.S., M.R.I., "Magnetic Rocks;" Friday, May 22nd, Professor J. A. Ewing, M.A., F.R.S., "The Molecular Process in Magnetic Induction."

Electricity for Gun Firing.—It has been decided to arm the sea front at Portsmouth, from Southsea Castle to Fort Cumberland, with guns, to which range finders will be fitted. It is also proposed to fire them electrically.

Important to Electric Light Companies.—On Tuesday last week, at Winchester Assizes, before the Lord Chief Justice of England and a common jury, the indictment, Reg *v.* The Fareham Electric Light Company, was tried. The local gas company were the real prosecutors in this case, and they indicted the defendants for having obstructed some highways in the town of Fareham by digging holes and erecting posts and wires. The posts, it was alleged, were an obstruction to the roadway, and in some cases were dangerous. At the end of the arguments, his Lordship said he must direct an acquittal. Undoubtedly the posts would have been an obstruction but for the statutory powers given to the Local Board by the Public Health Act, 1875. He then referred to section 161 of that Act, and said he considered "other means of lighting" mentioned in it included electricity, even although electric lighting was practically unknown when that Act was passed, and that under the section the local board could contract with the electric light company. He directed the jury to find all the defendants Not Guilty.

Free Gossip.—The Paris correspondent of the *Standard*, telegraphing on Tuesday night, said:—"The public were permitted to-day to make use of the telephonic cable to London without payment. The telephonic cabins in communication with London were those at the Bourse and in the Avenue de l'Opera; but there were fewer applicants than might have been expected, and after four o'clock at the Bourse there was not a single demand for communication with London."

The Westminster Electric Supply Corporation, Limited.—All the three stations of this Company are now at work. The Millbank Street Station was permanently started in November last. The station at Eccleston Place was started on the 2nd ult., and that at Davies Street, which supplies Mayfair (down to Piccadilly), was started on the 24th. In the two cases last named, the permanent machinery is enclosed in a temporary iron building, covering over a portion of the engine and boiler rooms, while the building of the rest of the station proceeds. The time which elapsed between the signing of the building contract and the delivery of current from permanently installed plant was seven months and three days in Eccleston Place, and exactly six months in Davies Street, although work was practically stopped for nearly two months in the winter owing to the severe frost.

The Electric Light at Bath.—The Surveying Committee of the Bath Town Council have had before them an application from Mr. H. G. Massingham for permission to light premises outside his area. It was stated that he had power to go 30 feet beyond, but the premises in question were 300 feet beyond. A question being raised whether Mr. Massingham had sufficient power at the works, it was stated that according to Prof. Forbes, who recently visited Bath, Mr. Massingham now has more machinery.

Electric Lighting at Brighton.—The work of laying mains for the supply of electricity by the corporation is now well advanced, and it is expected that a large number of householders in the area to be first supplied will avail themselves of the illuminant. A local firm of electrical engineers have fitted up an installation on their premises, where lamps and fittings of all kinds can be seen at any time in action.

The Electro-Harmonic Society.—The last Smoking Concert of the fifth season takes place on Friday evening next, when a very strong programme (see p. 12 of Advertisement Supplement) will be presented to members and friends. A novelty will be the vocal quartette of choir boys, and the famous D minor concerto for two violins by J. S. Bach will be performed. This remarkable composition is rarely heard outside the sacred precincts of that part of St. James's Hall devoted to the Monday and Saturday Popular Concerts of classical music, and we think that the musical directors will find that they are justified in bringing it forward, for the first time we imagine in the whole history of smoking concerts. The songs of Mr. Wm. Nicholls, and also those of Mr. Bevan, are sure to please, and in Mr. Cozens we have, in the humorous way, a new candidate for favour. The instrumentalists are old and tried friends of the Society, so comment upon them would be superfluous.

Patent Rights Question.—A correspondent writes:—"Will any reader say whether a patent already taken out, claiming *frictional or static* electricity only, would make a patent every way different in its application, though for the same purpose or use as above, void, or useless, if I get the supply of electricity from a small dynamo? Not knowing an electrician I am unable to get at the above information. Kindly give some good work confirming it." Personally we should say that our correspondent is quite at liberty to use dynamic electricity, unless this has been mentioned in the body of the specification which claims frictional or static. Perhaps, however, he can send further details, which would render it easier for us or any one of our readers to answer with more certainty.

Reduction in Telephone Charges.—The charges for the use of the Post Office Telephone Exchanges in the country have been reduced. Subscribers within a quarter of a mile of the Exchange will in future pay £8 a year, half a mile £10; three-quarters of a mile, £12; one mile, £14 a year.

Boiler and Engine Tests.—At the ordinary monthly meeting of the Leeds Association of Engineers, held on Thursday evening, last week, Mr. Henry McLaren, of the firm of Messrs. J. and H. McLaren, engineers, Hunslet, read a paper on "Boiler and Engine Tests." He stated that the engine and boiler was a most extravagant machine, only some 2 or 4 per cent. of the heat contained in the coal being given off by the flywheel of the average engine. While the engine and boiler combined was so extravagant, the boiler alone came out fairly well, a good locomotive type boiler giving off as much as 80 per cent. and up to 84 per cent. of the total heat contained in the coal, though 70 to 75 per cent. might be considered a satisfactory result. The best engine, however, only gave 15½ per cent. of the value of the steam passed from the boiler in the form of useful work.

Behind the Age.—The *Newcastle Weekly Chronicle Supplement* of March 21st, in speaking of the electric pinnace recently floated, says:—"The first vessel propelled by electricity was launched a week ago on the Thames . . . . the inauguration of electricity as a marine motive power is of considerable interest." A correspondent informs us that he wrote to the journal correcting these blunders, but his letter was not inserted; but that is the way of newspaper scientists.

Overhead Electric Light Wires.—A correspondent writes:—"I have read with interest your leading article on "Overhead Electric Light Wires," more especially so as I am now engaged in that work. There is one objection to the use of heavily insulated overhead wires, which I have not seen mentioned, although others must have experienced it, viz., the liability of the insulation to strip when it is held by the draw-vice. This, of course, occurs at the poles, particularly at the terminal poles, where a high insulation is most required. I think an insulation resistance that is "*uniform throughout*" would be quite as easily obtained by the use of a lighter insulated wire—say, 300 megohms per mile, at about two-thirds the cost, and would of course look much better when up."

Electric Lighting of Carlow.—The Town Commissioners of Carlow have made a 21 years' contract with Messrs. Gordon & Co. for the electric lighting of their town, and the works in connection with the installation are now approaching completion. Counsel is, however, of opinion that, under the 51st section of the Towns Improvement (Ireland) Act, the commissioners have no power to contract for the lighting of the town by gas, oil, or other means for a longer period than three years, and also that unless they take advantage of the provisions of the Electric Lighting Acts of 1882 and 1888 the commissioners cannot use or contract for the use of electricity as a public illuminant at all. The commissioners, however, consider themselves bound by the clause guaranteeing to Messrs. Gordon and Co. the sole right of public and private lighting by electricity, and have asked their solicitor to furnish a clause in place of the one expunged by counsel, which shall, so far as is possible, carry out the undertaking they had given before the installation works were commenced.

Barker's Patent Insulator.—A correspondent sends us a copy of *Answers* for February 21st, containing a paragraph which we give below. He asks: Is this where Mr. Barker obtained his original idea?—"Tom Jones, who recently complained in this page that he was unable to sleep owing to the noise caused by the telegraph wires fixed on the top of his house, is informed by a Penzance reader that the wires may be made quite silent by fitting an India-rubber tube round them and their attachments." We scarcely think Mr. Barker will deign to reply when we say that our correspondent's letter bears the ominous date of April 1st.

The Accident in Walbrook.—Mr. Williams, since the accident that befel him in Walbrook, has received from all sources so many friendly inquiries as to his condition that he desires us to make a brief reassuring reference as to his condition. Since his removal from the hospital he has been progressing very favourably, and happily the gas effects are now scarcely felt, but the fall he had still gives him the appearance of being "closed for alteration and repairs." He is now in the country recruiting.

Electric Safety Lamps.—The following letter appeared in a recent issue of *Engineering*:—To the Editor of *Engineering*: Sir,—The council are desirous of receiving exhibits of miners' electric safety lamps to be shown at the annual meeting of the Federated Institution of Mining Engineers, to be held in London on May 27th and 28th next. Intending exhibitors are desired to communicate with, or send their exhibits to, the secretary. Yours faithfully, M. WALTON BROWN, *Secretary*, Newcastle-on-Tyne, *March 24th*, 1891.

Elmore's Foreign Patents.—Mr. Alfred Chapman writes to a financial contemporary as follows:—"It is to be hoped that the ordinary shareholders of Elmore's foreign patents will make a determined stand against accepting depreciated shares in place of cash. They are entitled to cash, but the directors propose that they should accept in lieu thereof shares in the French and Austrian companies at their par value. These shares can at present be bought at a heavy discount, and the distribution of many thousands of them will send them still lower. Until the ordinary shares have received £10, nothing goes to the founders' shares; that is the reason of the fool's bargain now offered to the ordinary shareholders."

Elmore's Latest.—A correspondent writes the following to the *Financial Times*:—"I am glad to see your article on "Elmore's Latest," and thank you for putting the matter so plainly before your subscribers, which will doubtless be appreciated by the shareholders of the Elmore Company. By the way, it may not be known in commercial circles that Mr. Alexander Watt, the well-known author of "Electro-Deposition" and kindred works, has lately devised a process for the production of copper from its ores, which will, I think, cause quite a revolution in the production of this important metal. —I am, &c., SUBSCRIBER."

Italian Asbestos.—The United Asbestos Company have just issued a new catalogue containing particulars of the great variety of asbestos goods manufactured by them, including several novelties of special interest to electrical engineers. One of the illustrations gives a view of the nine Davey-Paxman boilers at the Paris Exhibition, which were covered with the company's asbestos composition to the satisfaction, in nearly every way, of Messrs. Davey, Paxman and Co. In the electrical department a special asbestos paper is made for dynamo work and very fine joints; asbestos tubes for electric light leads; asbestos cement for electric light leads, as recommended by the Phœnix Fire Office Rules; asbestos fireproof paint for protecting wood work, troughs for leads, &c.; asbestos millboard strips; fine asbestos thread for covering wires; asbestos covered wires; packing and jointing material for stationary engines; non-conducting covering for boilers and pipes and the patent "Salamander" lubricant for dynamos, &c. Consumers are are invited to draw the inference that, as the company is the only one in the world owning and working asbestos mines in both Italy and Canada, they are in the best possible position to meet the demand for asbestos goods of every class.

The Institution of Electrical Engineers.—On Thursday next the following paper will be read, "The Design of Multipolar Dynamos," by W. B. Esson, member.

Glasgow Electric Lighting.—Only Messrs. Mavor and Coulson, of Glasgow, R. E. Crompton & Co., the House-to-House Company, and the Thomson-Houston Company, have tendered for the Glasgow lighting. The Special Committee on Electric Lighting has not come to any decision on the subject of the tenders.

Underground Cables.—Of the various causes of trouble with underground cables which have been efficiently laid, probably mechanical injury will be found to be the most fruitful. The Chicago Arc Light and Power Company had in operation last year 28½ miles of duct occupied by high-tension underground circuits, 29 miles of lead-covered cable in ducts, and 72 miles of cable in iron pipes or bracketed under side-walks for distribution. The total length, however, of underground high-tension cable was 151 miles, and the number of cases of trouble in 1890 was 31. Of these, eighteen were due to mechanical injury, four to defective joints, two to defective insulation, whilst the cause of the remaining seven burn-outs was not accurately determined.

Cable Manufacture in France.—The following note appears in the *Bulletin International de l'Electricité*:—"In our issue of the 9th March we reproduced an article from the *India-Rubber World*, which stated that, encouraged by the French Government, an American company was about to establish a factory for telephone cables in France. We are, however, convinced, after enquiry, that this report has but little foundation beyond an attempt to allure American capital hitherto refractory. It is equally certain, notwithstanding the advocacy by certain people of a system which even in America is looked upon with suspicion, that the French Government will not lend itself, even unconsciously, to an American advertisement. It must be admitted that the fondness exhibited by the Administration of Posts and Telegraphs for seeking abroad that which can be found equally well at home has a tendency to encourage this sort of hallucination. But we have every reason to believe that the administration has come to consider, with a sentiment of greater justice, the claims of our national industries, and that it will not repeat the costly experiments of later years."

Gibson Accumulator.—In America the Gibson indestructible battery is said to be in extensive use, and is strongly backed financially. It is now being introduced into England under like auspices, so that the merits of the accumulator will have the best of chances of being demonstrated before the public in this country, and success if secured will, as in many other American patents, be partly due to the inherent good qualities of the invention, and partly to the sound business way in which it is exploited. The owners of the patent consider that their secondary battery is outside of any other patents, and that it is also much more efficient electrically, and from a mechanical point of view exhibits a superiority for strength and for freedom of liability to accidental derangement. The cells have been under test by the India-Rubber and Gutta Percha Company for some months, with a result every way satisfactory. They have been charged rapidly, and a heavy current has been discharged from them. Under these conditions of trial they are apparently none the worse; the active material is firm, and the plates are free from buckling. It is said that a 200 ampère-hour cell, weighing between 40 and 50 lbs., compares favourably with a 400 ampère-hour E.P.S. cell when tested under similar conditions. The plates in the cell are placed horizontally, first a negative and then two positive, then a negative and so on, a complete cell, consists of six negative and five double positive plates bolted together. The plate itself is a perforated tray about ¼ of an inch deep, with stud holes at intervals for the bolts, over each perforation in the bottom of the tray there is a kind of loop which comes up flush with the edge of the tray. The tray is then filled with active material in powder, treated, put together to form a cell, and formed. The loops in the tray securely hold the active material in its place. We shall be curious to learn how the holders of the E.P.S. patents regard the Gibson accumulator, whether as a rival or a possible infringer.

Electric Lighting of Manchester's Largest Railway Station.—The numerous platforms of the Victoria Railway Station in Manchester are now lighted by electricity.

Easter Monday and the Electric Railway.—The directors of the City and South London Railway announce that they carried 25,000 passengers on Monday last.

Camera Club.—The fifth annual conference of the Camera Club will be held at the Society of Arts on Tuesday and Wednesday next, April 7th and 8th, to which all photographers are cordially invited.

The Board of Trade Requirements!—We hear that the town of Taunton is being rewired to meet the Board of Trade requirements. Perhaps when finished the technical adviser to the Board will discover something which will necessitate still another change.

Berlin-Munich Telephone Cable.—It is proposed to lay an underground telephone cables between Munich and Berlin. The Bavarian Government is greatly interested in the project.

The Paris-Brussels Telephone.—It is intended to reduce from five to three minutes the time allowed for conversation on this line during the busy hours of the day, but two consecutive communications—that is, six minutes—will be permitted. It has been found that 80 per cent. of those using the telephone occupy less than five minutes in doing so.

Electrical Engineers Students.—A general meeting of the students was held on March 20th, when the following papers were read, "Gutta Percha," by Mr. H. C. Haycraft; "Commutators," by Mr. J. H. Garret. At the next meeting, on April 20th, a paper will be read on "Photometry," by Messrs. Matthews and Seaman.

Such is Fame!—The *Pall Mall Budget* of March 26th contains a full-page illustration of the scenes connected with the completion of the Paris-London telephone. Amongst other sketches we notice the head of a gentleman, labelled Mr. W. H. Preece, F.R.S. This was highly necessary, for his most intimate acquaintances would otherwise have failed to recognise the Chief Electrician to the Post Office.

Electric Lighting Tender.—A despatch has been received at the Foreign Office from her Majesty's Minister at Belgrade, stating that the municipality invite tenders down to the 1st (13th) of April, for lighting that town by electricity. The concession will be granted for a period of 41 years from the date of its signature, and further particulars may be seen on application at the Commercial Department of the Foreign Office.

Illuminating Gas.—*Harper's Magazine* contains the following:—"Dwellers in small country towns not unfrequently have to put up with a very inferior quality of gas. It was while suffering from a lack of proper illumination that a consumer penned the following request to the president of the gas company in his town. *September 25th*, 1890.—President, Dear Sir,—I see in the paper published in this town that your company advertises 'illuminating gas.' Will you be so kind as to send me a tankful of this to enable me to discover the whereabouts of the ordinary gas you furnish when lit. Faithfully yours, ———."

Electric Call System and the Post Office.—Arrangements have been made by the Post Office for the establishment of an electric call system in connection with the Telegraph Office in West Strand. The instruments used will be telephones. A number of boy messengers will be stationed at the West Strand Telegraph Office, so that a subscriber will be able, by means of the telephone, to summon a boy for the express delivery of a letter or parcel. The West Strand Telegraph Office will also be connected by telephone with the Corps of Commissionaires, so that in the event of a subscriber requiring the services of a commissionaire he can be immediately placed in direct communication with the offices of the corps. The telephones are being fixed experimentally in some of the neighbouring clubs and hotels.

The Old Students' Association.—A paper has been promised for this session by Dr. Silvanus Thompson, on "The Recent Advances in Optics," and a smoking concert has been suggested for the 24th inst.

The Appeal on behalf of Mrs. Frank Thorne.—We are desired to say that the widow of the late Mr. Frank Thorne tenders her thanks to those who responded so generously to the appeal made on her behalf.

The Electrical Accessories Company, Limited.—Owing to the increase in the business of the company, it has been found necessary to modify the arrangement of the staff, and Mr. C. L. Schwind, son of Mr. Charles Schwind, the chairman of Messrs. Handysides, of Derby, has been appointed manager.

Personal.—Mr. A. D. Stevenson, who has for some years acted in the capacity of manager in the offices of Messrs. Drake and Gorham, has been compelled to abandon the work on account of failing health, and has decided to leave for South Africa, where he will practice as an electrical engineer with Mr. Edlin. The partners and 70 of the *employés* of the firm have presented him with a Wheatstone bridge and a stationery cabinet as a memento of his connection with the business.

The London-Paris Telephone Service.—The *Times*, in its issue of yesterday, says that at the request of the French Telegraph Administration the Anglo-French telephone line was thrown open for gratuitous trials on Tuesday, and the line has been at the service of the public, on paying the fees, since the ensuing midnight. Although there has not been any "rush" to use the line, it is said the traffic has been all that could be desired, and our contemporary understands that it has given every satisfaction to the promoters of the undertaking. We think, however, that this information shonld be taken *cum grano salis*, for we hear that the highest number of conversations reported as having passed over the line on Wednesday was not above 20, the receipts amounting to a sum of £8, and yesterday we believe was much the same. What if city men fight shy of it altogether?

NEW COMPANY REGISTERED.

The Froude-Hurrell Torpedo Company, Limited.—Capital £10,000 in £10 shares. Objects:—To adopt an agreement, dated the 7th ult., between M. H. Hurrell of the one part, and J. W. Leppard for the company of the other part, to construct, manufacture, purchase, sell and deal in torpedoes, high explosive projectiles, shells, cannon, cartridges, powder, explosives and other appliances for military and naval operations, to manufacture, establish and work apparatus for the distribution and utilisation of electric and other power, to construct, establish, purchase, hire and deal in railways, vessels, telegraphic and telephonic wires, instruments and appliances, and for other purposes. Signatories: W. C. E. Sergeant, 3, Elm Court, Temple, E.C. (1 share); J. Nelson, 3, Whitehall Place, S.W. (21 shares); M. H. Hurrell, Fair View, Dartmouth (1 share); E. R. Crump, 15½, Parliament Street, S.W. (1 share); R. H. Froude, The Keep, Dartmouth (20 shares); J. Viney, 6, Dunster Gardens, Brondesbury, N.W. (1 share); C. W. E. Henslowe, Grayshott, Hants (10 shares). The number of directors is not to be less than three nor more than four, exclusive of a director to be appointed by M. H. Hurrell. Qualification, £50. Remuneration of chairman, three guineas; director, two guineas per attendance at board meeting. Registered on 24th ult. by H. C. Knight, 2, South Square, Gray's Inn. Registered office, 2, South Square, Gray's Inn, W.C.

Submarine Cables Trust.—Notice is given that on the 15th instant the coupon due in October last will be paid in full by Messrs. Glyn, Mills, Currie and Co.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending March 27th, 1891, amounted to £5,427.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 27th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £4,431.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (Mar. 25)	Closing Quotation. (April 2).	Business done during week ending April 2, 1891. Highest.	Lowest
250,000£	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,381,380£	Anglo-American Telegraph, Limited	Stock	47 —48	47 —48	...	...
2,809,310£	Do. do. 6 p. c. Preferred	Stock	84½— 85½	84½— 85½	85½	84⅜
2,809,310£	Do. do. Deferred	Stock	11 — 11½	11 — 11½	11⅜	...
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼xd	11¾— 12 xd	12	11⅝
84,500£	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000£	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	103 —107	103 —107	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2⅜— 2⅝	2⅜— 2⅝	2⅝	2½
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1⅝— 2	1⅝— 2	1⅞	1½
50,000	City and South London Railway, Nos. 1 to 50,000	10	5½— 6½	5½— 6½	...	...
$7,216,000	Commercial Cable, Capital Stock	$100	107 —109 xd	107 —109 xd	108⅛	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	7/16— 9/16	7/16— 9/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	5 — 5½	5 — 5½	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	...	...
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼xd	3¾— 4¼ xd	4⅛	4 1/16
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10 xd	...	...
60,710	Direct United States Cable, Limited, 1877	20	10⅛— 10⅜	10⅛— 10⅜	10⅜	10 5/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅛— 14⅜	14⅛— 14⅜	14⅜	14 3/16
70,000	Do. 6 p. c. Preference	10	15⅛— 15⅜	15⅛— 15⅜	15⅜	15⅜
200,000£	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	107¾	...
1,200,000£	Do. 4 p. c. Mortgage Debenture Stock	Stock	107 —110	107 —110	...	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14¾— 15	14¾— 15⅛	15⅛	14 15/16
91,800£	Do. 5 p. c. (Aus. Govt. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	...	...
325,200£	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	104 —107	106½	105½
320,000£	Do. 4 p. c. Debenture Stock	Stock	104 —107	105 —108	106½	...
145,300£	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
198,200£	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	...	...
201,600£	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5½— 6½	5½— 6½	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1 — 1⅛	1 — 1⅛	1⅛	...
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	3 — 3½	3 — 3½	...	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 — 1½	1 — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅛— 9⅜	9⅜— 9⅝	9 5/16	9⅛
180,042	Do. do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15 1/16	...
150,000	Great Northern Tel. Company of Copenhagen	10	17 — 17½	17¼— 17¾	17¼	...
220,000£	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	103 —106	103 —106	...	...
9,384£	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10½— 11½	10½— 11½	...	...
5,334£	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	19 — 20	18½— 19½	19¼	...
200,000£	Do. do. 4½ p. c., Deb., 1896	100	102 —104 xd	102 —104 xd	...	...
17,000	Indo-European Telegraph, Limited	25	39 — 41	39 — 41	40½	40
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7 — 8	7½— 8½	7⅞	7⅝
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9¼— 9⅝	9¼— 9⅝	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6½— 7½	...	...
100,000£	Do. do. do. 6 p. c. Debentures	100	105 —108	105—108	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	8⅜— 9½	8⅜— 9½	9	8⅞
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜— 4⅝	4⅜— 4⅝	4⅝	4 7/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	12⅜— 13½	13 — 13½	13⅜	13¼
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	10 — 10½	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	5/16— 7/16	5/16— 7/16	9/32	...
9,000	Reuter's Limited	8	8¾— 9¼	9 — 9½	...	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2¾— 3½	3 — 3½	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	...	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4½— 5	4½— 5	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	45 — 47	46½	46
150,000£	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	3 — 4	2½— 3½	...	...
146,128£	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
3,200£	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,089	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900£	Do. do. do. 5 p. c. Debentures	100	97 —100	97 —100	...	...
30,000	West Coast of America Telegraph, Limited	10	2 — 3	2½— 3½	...	...
150,000£	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	92 — 97	92 — 97	95	93
64,174	Western and Brazilian Telegraph, Limited	15	12 — 12½	12 — 12½	12⅜	12⅛
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 7¼	6¾— 7¼	7	6⅞
27,873	Do. do. do. 5 p. c. Deferred	7½	5¼— 5¾	5½— 5¾	5½	...
200,000£	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000£	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	103½	...
88,321	West India and Panama Telegraph, Limited	10	2⅜— 3	2⅜— 3⅛	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	...	...
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11½— 12½	11½— 12½	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
175,100£	Do. do. 6 p. c. Sterling Bonds	100	100 —104	100—104	...	...
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	3⅞— 4⅛	3⅞— 4⅛	4	...

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅜.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 27—30.—Elmore's Austrian Copper Depositing, 20s., 10s. Dis.—Elmore's Priorities, 3⅜—4.—House to House Company (£5 paid), 4¾—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅜—2⅝.—Manchester Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 6¼—6½.—Woodhouse & Rawson Ordinary of £5 (£2 10s paid), 2—2½.—Preference, fully paid 3⅞—4⅜.—Debentures 90—95.—Woods Electric Car, £10 paid, ⅜—1.

BANK RATE OF DISCOUNT.—3 per cent. (29th January, 1891).

PROCEEDINGS OF SOCIETIES.

Society of Arts.

Electricity In Relation to the Human Body, Its Dangers and its Uses.*

By H. Newman Lawrence, M.I.E.E., and Arthur Harries, M.D., A.I.E.E.

(*Concluded from page* 414).

Repeated qualitative tests have shown clearly that the drug used has passed into the system, and we are now endeavouring to obtain quantitative tests which we hope may lead to the adoption of definite dosage by this method.

While on this portion of our subject, it might be well to refer to some experiments we have made to determine whether electricity can be passed from rubber to rubbed in the act of massage. For this purpose, several readings were taken from both operator and patient before and after the operation; and it was found that, while in all cases the patient gained electrically by the rubbing, in most the operator gained also. In some other cases, though the operator gained nothing, or even lost a little, the loss was not at all proportionate to the gain of the patient. These results, we think, are amply accounted for by the fact that exercise seems always temporarily to increase the body currents, provided it be not sufficiently violent or long sustained to cause exhaustion. Massage acts upon the patient by improving the circulation and emptying the lymphatics, and so, to that extent, is akin to gentle exercise; hence the increase of the body currents noted in the patient. Massage is to the operator often more than gentle exercise, and is frequently accompanied by a certain amount of exhaustion. Any gain in body current on the part of the operator is probably due to the exercise taken; but this gain may be rendered negative by accompanying exhaustion. We are thus led to conclude that electricity does not pass from rubber to rubbed in massage.

Since writing the above, our attention has been called to an American invention, which is designed to prove of use to the body in dentistry. It is called a "Dental vibrator," and its object is to render painless that very unpleasant operation, "tooth extraction." We have examined and tested it in use, with the result that, as far as our present observation goes, we find it does fully accomplish the elimination of pain.

In conclusion, it may perhaps be well to say a few words by way of summary.

The dangers of electricity to the body are considerable, but, fortunately, they are provided against, and generally in a very secure manner. Consequently, it is probable that possible danger to the body from electricity, as carried by light and power circuits, is smaller than the danger connected with the use of gas or oil. Still, let it not be forgotten that danger, sharp and sudden danger, lurks in the conductors of such circuits, and therefore none but properly initiated and protected persons should touch or interfere with them. If only the wires or other conductors of light and power circuits be so insulated and placed that, under ordinary circumstances, the body cannot come into contact with them, risk is light and danger small. It, in fact, concerns only the comparatively few, whose work necessitates their constant presence among such conductors.

The uses, however, affect a far larger number, and outweigh the dangers to an enormous extent. Electricity is useful to us in health; it is so closely connected with vital function and sensation that very probably life does not exist without it; it is capable of producing such changes in the body, that it takes rank as one of the best remedies in disease, and it is also of immense value in many branches of surgery.

The true relationship between this marvellous and many-sided agent of Nature, and the various complicated phenomena which together make up the sum of our individual existence, has yet to be found. We venture, however, to think that what has so far been discovered proves the relationship to be beneficent. The more the subject is investigated and studied, the better it will be for the health and happiness of us all.

During the reading of the paper, Dr. Harries illustrated the cataphoric method of using cocaine on a subject, and explained the process as follows:—

I am only about to show you a single experiment this evening, and for the following reasons. First of all the initial experiments, which are really the basis upon which we propose to proceed to-night, are only workable with large currents. Now, it is not easy to apply these large currents to the body, because people object to have painful currents used. Further than that, it would be unfair to use such currents as would be likely to come into contact with the skin by accident; and, as a third reason, one would only wish to use such currents as might really be of service to the body. What we are going to do is to place some electrodes in contact with the skin of the gentleman who is good enough to be our subject. By means of these electrodes we shall send a current of 20 m.a. through the moistened skin. One of the electrodes will be saturated with a solution of cocaine, which is, as you know, an anæsthetic, and we hope at the end of twenty minutes or so to be able to have so anæsthetised the skin as to be able to operate upon it painlessly. We shall prove that the part is insensitive, by passing a needle through it, and still further by sending a small current through the skin. To prove that the current has been used, I shall take away one or two hairs by electrolysis, so as to give you ocular demonstration of what has been done. I will endeavour to show on the blackboard an outline of the experiments which form the basis on which the process of cataphoric medication has been built up.

We start with a couple of beakers filled with fluid nearly to the brim; one containing dilute sulphuric acid, the other a solution of barium chloride. Between the two we place a piece of lamp-wick well soaked in a solution of sodium chloride. It may be supposed that, by simple capillary action, some of the hydric sulphate may pass over into the barium chloride, but that is not so, as we proved by leaving the apparatus in *statu quo* for twenty-four hours without any such result. Then we modified the conditions by placing in the first beaker an electrode connected with the positive pole of the battery, and in the second another electrode connected with the negative pole; and sending a current of about 100 m.a. through the arrangement. Within half an hour we had a deposit of barium sulphate; in fact, in a few minutes a little dulness could be seen in the liquid at the end of the lamp-wick; the dulness soon spread, and ultimately flakes could be distinguished. These were remarkably fine, and it was necessary to look at them with a lens to distinguish them from the bubbles of hydrogen which were given off in great quantity. That is the first step in our series of experiments. You may say that the whole thing is easily explicable by the theory of electrolysis; but that is not so, and for this reason. If we were experimenting by means of electrolysis only, we should use some solution in which the alkaline element would be carried to the negative electrode; but here we have no alkaline element present at all, with the exception of hydrogen, and that, of course, would not produce a precipitate in the barium chloride solution. There must, therefore, be something else at work. Having put capillary attraction out of the question by our initial experiment, we may ignore electrolysis because there is nothing to pass over which will produce a precipitate. We have therefore to consider the third power of a continuous current, viz., that of mechanical transference, and, as a matter of fact, we have an absolute mechanical transference from the positive electrode to the negative. The proof of that is found in the precipitation of barium sulphate in the second solution. Of course if we were going the other way about, it would be easy enough to produce a precipitate; but we have used the sulphuric acid purposely at the positive electrode, in order that there may be no possible question of any other kind of action.

The next experiment is a development of the first. Here we have a trough made of glass, divided into two parts by a porous septum, which in our experiments was made of baked clay. It is not very thick, but just sufficiently so to prevent any chance of leakage. Into one of these compartments we place a solution of iodine, and in the other is a solution of starch. The reason iodine dissolved in water was selected was that we should have no chance of complication from such solutions as might be dependent on the presence of an iodide salt. Supposing, for instance, we had used iodine dissolved in water together with iodide of potassium, under the conditions of the experiment, the potassium would be passed over, and we did not want that to happen. We tested this arrangement, to see if there were any precipitation of the starch in the ordinary way, by simple osmosis, and we found no result whatever. But when we placed an electrode in each compartment, one connected with the positive, the other with the negative pole of the battery, and sent a current through, we found that, within an hour, there was distinct precipitation of iodide of starch, which went on increasing for a considerable time. It was not large in quantity; that is a point to be noticed. Had it been large in quantity, it would have upset some of the points in connection with cataphoresis which I am anxious to make clear. As a result, therefore, of the action of a continuous current applied in this way, we passed iodine through the porous plate into the starch solution, and had on one side a precipitate of iodide of starch. The precipitate did not continue to increase after a certain time. There are chemical reasons for that, but it is sufficient to say that we did have a precipitate which was sufficiently copious for all the purposes of demonstration.

The third step is this. In place of the porous plate, we choose to-night for the purpose of our experiment the human skin—that is, a septum of animal membrane—and by means of this power of mechanical transference of continuous current, I hope to be able to show that cocaine can be passed through the skin in such quantity as to enable us to anæsthetise it completely. We use a small pad soaked in a solution of cocaine, which is placed on the part of the skin to be operated upon. The negative electrode is fixed a little higher up the arm, and the part between the two represents the porous septum, or lamp-wick. We have allowed a current of about 20 m.a. to pass through the skin for 25 minutes, and doubtless, on removing the pad, I shall find the skin quite insensitive to pain. The first thing one notices is that the skin underneath the electrodes is red; that is merely an exemplification of the ordinary action. Now, taking a platinum needle which can be connected with a battery, I pass it through the skin to the depth of $\frac{1}{10}$th inch or more. The subject shows no sign of pain. Now I put on a current of 4 m.a. The first thing one observes is a separation of gas at the point of application of the needle. On removing the instrument, I find that the hair easily comes away from the skin, the root being more or less decomposed. I will take away another hair in the same way, passing the needle well down to the base of the follicle.

Discussion.

Mr. Howard Swan said he had watched the progress of these experiments from the beginning with great interest, and believed the investigation was likely to prove very useful. The power of treating a small portion of the human body, so that it might be actually cut into without causing pain, needed no words to recommend it to medical men. Though in ordinary houses there was no danger from electric wires, it was useful for the public to know what dangers lurked in the wires, with which they had no business to meddle, especially as recent experiments showed that currents of far greater pressure than we had been accustomed to—even up to 25,000 volts—were likely to come into use. He had heard of several sets of experiments with regard to electricity being generated in the human body,

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* Read Wednesday, March 11th.

but did not know whether the actual amount of current had been determined. A friend of his, late cable superintendent to the Eastern Telegraph Company, told him that that he had sometimes amused himself by testing both negroes and himself, and found that the potential of Europeans was considerably greater than that of negroes. It varied in different states of health and activity, and it occurred to him that it might be an aid to diagnosis. If the normal current in a healthy state had been determined, it would be probably found to vary in disease. One question was how far the process of digestion gave rise to these currents. If there were any reason to suppose that the human stomach, at a temperature of 100°, was a primary battery, it might afford a useful hint to electricians, and if they employ, not necessarily a solution of corn, but say of coal ground fine, in a battery of which the prototype was the human digestive organ, there might be a great development of primary battery schemes. Dr. Milne Murray read a paper lately at Glasgow, in which he brought forward a very delicate galvanometer of the type spoken of by Mr. Lawrence, in which there was a special arrangement for determining minute physiological currents, and if any further information could be given on that point it would be interesting.

The CHAIRMAN said both the dangers and benefits of electricity were now attracting a good deal of attention, and each topic was a very old one. There was this great distinction between this paper and nearly all that had hitherto been written on the curative qualities of electricity, that it had been illustrated by experiment, and was the result of actual observation. Too often people allowed their imagination to run wild on these matters. The dangers of electricity had occupied a great deal of attention lately, and the Press had given great prominence to accidents which had occurred in the United States. Nearly all these accidents had arisen from men occupied in repairing and maintaining telegraph and telephone wires, who had received severe shocks, and had been killed, either instantly by the current, or by being thrown from great heights to the ground. But, in these cases, the currents were not from the telegraph wires themselves, but from electric light or power circuits which ran on the same poles. Those who had not been in the States could scarcely believe that a nation so far advanced in civilisation would actually allow a street like the Strand to be permeated by poles, each carrying a mixture of wires—some telegraphic, some telephonic, some for fire alarms, and many for electric lights and the transmission of power. The result was, you could walk down Broadway almost sheltered from the sun by the cloud of wires overhead. When a poor telegraph man ascended a pole to remove a fault, he might accidently touch a wire carrying a powerful current, from which he received a fatal shock; but, of some 30 accidents he had investigated, about nine-tenths had arisen from this cause. Of course, the cure for such dangers was very simple. The first rule was, never to allow such wires to be carried overhead. All light and power wires worked at high pressure should be carried underground, away from the reach both of the public and the workmen. But in this country there was an element of safety which existed nowhere else that he knew of, and which few people liked—the grandmotherly government of the Board of Trade. But there never was an institution which did more for the life and health of the country than the Board of Trade. Its rules and regulations had made a first-class railway carriage absolutely the safest place to live in; for more people died in their own dining rooms than in railway carriages. The same with electric wires; if they were put up in accordance with the rules of the Board of Trade there would be almost absolute safety. One important point in connection with the danger from wires was the duration of contact. You might have a current of high E.M.F., snd just touch the wire with more than a trifling effect; but if you grasped it, and got muscular fixation, the result would be very serious. Another point of great importance, which had been lately investigated by an American electrician, Mr. Tesla, was the influence of alternating currents of high frequency. The authors spoke of an alternating current of a frequency of 23 to the second; but those used by the Grosvenor Gallery Company were about 70 or 80, and at present the ordinary frequency used was about 100. Mr. Tesla found that the higher the frequency, the greater was the amount of electrical energy which might be passed through the body without serious discomfort, which was a point deserving attention. The authors trod on very safe ground when they applied their powers of experimenting to solve this intricate question. Tooth extraction had been spoken of, and a friend of his had tried the electrical method and found it so successful, that he had eight troublesome teeth removed at one sitting.

Dr. HARRIES, in reply, said it had not been possible, with the instruments at their command, to determine the exact difference of potential at different parts of the body. They found deflections varying from 15 or 20 up to perhaps 40 degrees on the scale of the mirror galvanometer, but what that represented he was unable to say; each degree might be one-millionth part of a unit, or perhaps less, but at present that was only a guess. With regard to the difference noted between negroes and Europeans, that might in all probability be accounted for by a difference in skin resistance. The skin of a negro was usually much thicker than that of a white man, and was the chief factor in the resistance to the passage of currents generated inside the body. The question relating to the process of digestion would admit of a great variety of answers, but he should suppose that where digestion was going on there would be electrolysis, and, if so, there would be loss of current, not production. On the other hand, where oxidation was going on, as in the lungs, and in the tissues where action was vigorous, where the oxyhomoglobin of the blood was being reduced, you might expect to find production of current. He had not yet seen Dr. Milne Murray's galvanometer. As a rule anæsthesia began to diminish after about ten minutes, and went on diminishing for half an hour or 40 minutes, depending in different cases on the degree of soakage. The anæsthetic result depended, to a great extent, on good preliminary soakage of the skin, which, lowering its resistance, enabled the solution to pass more readily into the tissues. Where the skin was dry, the process would take longer, and be more difficult. Whether the insensibility was due to the cocaine alone, was a vital point. If the result were due to electricity alone, they would not need to use the cocaine; and if it were due to the latter alone, there would be no occasion to use electricity; it was due to combined action. The application of cocaine alone of the proper strength would have some effect; but when used with the aid of the current it produced such anæsthesia that you could, if necessary, apply a red-hot iron without much objection on the part of the patient. By using this cataphoric process, the *galvano-cautère* had been applied as much as half-a-dozen times, consecutively, to the same patient, at the same operation, without any sign of wincing. He had seen no reports of the application of photography in noting the effects produced by electricity; but he should be very glad if someone would carry out experimens in that direction, which could hardly fail to be useful, especially in determining the exact dose of current which a patient could bear. As mentioned by Mr. Wyles, they used a fresh wet string, or wick, at each experiment, as well as platinum or carbon electrodes, avoiding anything liable to easy decomposition. The duration of contact was an important point, which had been alluded to in the present paper as well as in previous papers referred to. With regard to currents of high frequency, he had dealt with that question both at a meeting of the Institution of Electrical Engineers last March, when he stated that the more rapid the alternations, the more nearly did the conditions resemble those of a constant current as regarded sensation; and at the British Association meeting at Leeds the subject was also dealt with. It was stated that a much larger dose of electrical current could be taken when the alternations were 300 per second than when they were 50 or 60. Everything new, of course, came from America, but in this instance he thought they had got ahead of Mr. Tesla.

Royal Society.

CROONIAN LECTURE.—"On the Mammalian Nervous System; its Functions and their Localisation determined by an Electrical Method." By FRANCIS GOTCH, Hon. M.A., Oxford, and VICTOR HORSLEY, F.R.S., B.S., &c.

(ABSTRACT.)

1. *Introduction.*

In the *Proceedings of the Royal Society*, No. 273 (vol. 45, 1889, p. 18), we published a preliminary account of some of the experiments of which the results are given in detail in our full paper.

In that communication we stated that the object of our work then was to endeavour to ascertain the character of the excitatory processes occurring in nerve fibres when either directly, *i.e.*, artificially, excited, or when in that state of functional activity which is due to the passages of impulses along them from the central apparatus. The most important way in which such a method could be applied was, obviously, one which would involve the investigation of the excitatory changes occurring in the fibres of the spinal cord when the cortex cerebri is stimulated. We must at once assume that the motor side of the central nervous system is practically divisible into three elements. (1.) *Cortical centres.* (2.) *Efferent* (pyramidal tract) *fibres*, leading down through the internal capsule, corona radiata, and spinal cord. (3.) *Bulbo-spinal centres* contained in the medulla and the spinal cord, and forming the well-known nuclei of the cranial and also of the spinal motor nerves.

It had already been determined, both by direct observation and by the graphic method (1), that certain areas of the cortex were connected with definite movements of various parts of the body, and (2) that while the complete discharge of the cortical apparatus was followed by a very definite and characteristic series of contractions of the muscles in special relation with the particular point excited, the effectual removal of the cortical central mechanism and subsequent excitation of the white fibres passing down through the internal capsule, &c., led to the production of only a portion of the effect previously obtained from the uninjured brain.

This method of observation in no wise showed what processes were actually occurring in the spinal and other nerve fibres, and although the ablation of the cortical centre to a certain degree suggested the extent to which the cortex acted, nevertheless it did not afford an exact demonstration of the same. Moreover, the data which the graphic method furnished were precluded, through their being muscular records, from determining what share, if any, the lower bulbo-spinal central nerve cells took, either in the production of the characteristic sequence of contractions or in the modification, whether in quality or in force, of the descending nerve impulses during their transit. It seemed to us that the only way to approach this subject would be to get, as it were, between the cortex and the bulbo-spinal system of centres. This would be accomplished if some means were devised of ascertaining the character of the excitatory processes occurring in the spinal fibres of the pyramidal tract when, upon excitation of the cortex, nervous impulses were discharged from cortical cells, and travelled down the cord.

The question as to the extent to which it is possible to obtain physical evidence of the actual presence in nerve fibres of excitatory processes, and thus to arrive at reliable data for the comparison of their amounts, is one which up to the present has been answered only indirectly, and that in two ways. First, by the extension of Helmholtz's classical experiment of determining the rate of transmission, and, secondly, by observing those variations in the electrical state of nerve fibres which Du Bois-Raymond discovered to be an invariable concomitant of the excitatory state. As will subsequently be shown in the historical retrospect, it is well known, through the researches of Du Bois-Raymond and others, that the fibres of the spinal cord, just as nerve fibres in the peripheral trunks, are charac-

terised by showing, when unexcited, an electrical difference between their longitudinal surface and cross sections; and, furthermore, that when excited, a well-marked diminution of this resisting electrical state is produced in the fibres of the cord, as in those of nerve trunks. Now, since such excitatory variations in the electrical state are presumably parallel in time and amount with the presence in the nerve of the series of unknown processes, termed excitatory, which a series of stimuli evokes, it was reasonable to presume that, if the cortex were discharging a series of nerve impulses at a certain rate down the pyramidal tract, there would be a series of parallel changes in the electrical condition of the fibres in the cord tract, and that, with a suitable apparatus for responding to such changes, these might be both ascertained and recorded. The accomplishment of a further purpose, viz., the localisation of both paths and centres by ascertaining the excitatory electrical effects in relation with them, was one of the main objects we had in view. In carrying it out, we found it was unnecessary to employ the electrometer, and, in fact, that it was advantageous to use the galvanometer, the record of which would be more easily and more accurately noted, since its graduation admits of far higher magnification. Moreover, with this instrument it was possible, by employing a series of stimuli, of known number and duration, to obtain quantitative results of definite comparative value, as will be shown further on; and thus, to compare both the size of different central paths and the amount of nervous energy discharged along the same path from different sources.

The plan upon which the full paper is framed is, first, to give an historical retrospect of the work of authors who have opened up the study of electrical changes in the central and peripheral nervous system; second, to describe at length our mode of experimentation, with special reference to the modifications which we have introduced, then to compare roughly the results we have obtained by our present method with those which had been previously ascertained by the graphic method, and so introduce the description of the facts which we have discovered, elucidating the physiology of the spinal cord, both in its relation to the higher centres, and to the peripheral nerves.

2. *Experimental Procedure.*

The observations were in all cases made on etherised animals (cat and monkey), with due regard to the special influence of the anæsthetic. The operative procedure was so designed as to provide for suitable exposure of a particular region of the nervous system for excitation, and of another part in which the electromotive changes evoked by the stimulation may be observed. The relative parts were as follows :—

Part exposed for excitation.		Part exposed for observation.
Brain (cortex and corona radiata)	...	and spinal cord.
Do. do. do.	...	and mixed nerve.
Spinal cord	...	and spinal cord.
Do.	...	and mixed nerve.
Mixed nerve	...	and spinal cord.
Spinal roots	...	Do. do.
Posterior roots	...	and mixed nerve.

The excitation was either electrical, chemical (*i.e.*, with absinthe and strychnine), or mechanical. In the former instance the duration and intensity were specially determined. The records were made by a Thomson high-resistance reflecting galvanometer, and a Lippmann's mercurial capillary electrometer.

The tissue, whether nerve or spinal cord, was so arranged for observation as to be always suspended in the air, one end remaining in connexion with the animal; consequently any error due to current deviations from the rest of the body could only have a slight and unipolar effect.

3. *Resting Electrical Difference between the Cut Surface of the Tissue and its Uninjured Longitudinal Surface.*

The average amount of this difference in the tissues observed were as follows :—

	Cat.		Monkey.
Nerve (69 cases), 0·01 Daniell	...	(12 cases), 0·005 Daniell.	
Root (5 cases), 0·025 „	...	—	
Cord (50 cases), 0·032 „	...	(9 cases), 0·022 „	

We have observed that the cord difference is greater when that tissue is in connexion with the higher centres, and that it rises after each excitation. An important fall of the difference is to be remarked in all three tissues as a direct result of systemic death.

4. *Electrical Changes in the Spinal Cord evoked by Excitation of the Cortex Cerebri and Corona Radiata.*

We further discuss in our full paper the following points additional to those described in our previous communication, and which have resulted from the observation of the above changes :—

(*a.*) Localisation of cortical areas of representation in relation to the various regions of the cord.

(*b.*) Bilaterality of representation in the central nervous system, as evidenced by the electrical changes in the two halves of the spinal cord, consequent upon excitation of the brain or cord.

5. *Electrical Changes in the Spinal Cord when Evoked by Direct Excitation of its Fibres, after Severance from the Encephalon.*

We have by employment of this method ascertained the proportionate existence of direct channels in the various columns of the spinal cord, our design embracing the quantitative comparison of the electrical changes (and so indirectly of the nerve impulses) which are transmitted as a result of minimal excitation of the fibres. To further control our observations on these points, we have also determined the extent of interruption in any given channel by intervening sections of the same.

As an extension of this subject, we have investigated the concurrent spread of nervous impulses to collateral paths, and probably to centres, when this further condition is introduced by increase in the stimulus.

The above results have been obtained in the case of both ascending and descending impulses.

Among other general conclusions from this division of our research are the following :—

(1.) High degree of unilaterality of representation in the spinal cord.

(2.) Spread of impulses from one posterior column to another, and from one posterior column to its neighbouring lateral column through centres.

6. *The Relation of the Paths and of the Bulbo-Spinal Centres in the Spinal Cord to the Peripheral Nerves and their Roots.*

We have investigated this important relationship in the following modes :—

(I.) *The Electrical Changes in the Spinal Cord evoked by Excitation of a Mixed Nerve or its Roots.*—The chief conclusions which have been deduced from the results of these experiments, by means of minimal excitation and the employment of the method of blocking by intervening sections, include the following :—

(1.) Complete obstruction offered to centripetal impulses reaching the cord by the central end of the anterior root.

(2.) Mode of conduction, direct and indirect, in the cord of centripetal impulses passing up the posterior root.

(3.) Localisation of the direct path of afferent impulses in the posterior column of the same side as that of the nerve or root excited.

(4.) Localisation of the indirect path of afferent impulses in the posterior columns of the same and the opposite side and the lateral column of the same side as that of the nerve excited.

(5.) Proportionate development of both systems of paths in the two sides of the cord.

Expressed in percentages of the total transmission, this proportion is as follows :—

Posterior column of same side as the excited nerve	...	60 p.c.
Lateral column of same side as the excited nerve	...	20 „
Posterior column of opposite side to the excited nerve		15 „
Lateral column of opposite side to the excited nerve	...	5 „

(II.) *The Electrical Changes in a Mixed Nerve or its Roots evoked by Excitation of the Spinal Cord.*—Whereas in the foregoing series (I.) we dealt only with ascending impulses, we proceeded to investigate the distribution of descending impulses by observing the above-named changes when the individual columns of the cord are excited by minimal and later with more intense stimuli, controlling our results by the method of intervening sections.

We can summarise the effects observed as follows :—

(1.) Marked quantitative diminution suffered by impulses, leaving the spinal cord by the anterior roots, whether originating in the cortex cerebri, corona radiata, or the lateral columns of the cord.

(2.) Localisation of direct transmission of impulses in the posterior column and passing out into the posterior roots of the same side.

(3.) Proportionate development of the direct and indirect paths in the individual columns of the cord, passing out into the mixed nerve of the one side.

(4.) Effects observed in the posterior roots when the bulbo-spinal centres are excited either by strychnine or electrically (kinæsthesis.)

Finally, the chief general principles elucidated by this research may be stated as follows :—

(1.) Unilateral character of the representation of function in the paths of the central nervous system.

(2.) The physiological characteristics of the regions of a nerve centre :—

(*a.*) The kinæsthetic activity of the afferent region of the centre.

(*b.*) The obstruction offered by the efferent region, including the field of conjunction, to the transmission of impulses through the centre.

Physical Society, March 6th, 1891.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

Mr H. A. Miers, M.A., and Mr. W. Lucas, M.A., were elected members of the society.

Mr. James Swinburne read a "Note on Electrostatic Wattmeters." After referring to the history of the electrometer method of measuring power developed by alternating currents, the author pointed out that the necessity for taking two readings from which to determine the watts, might be obviated by having the quadrants separate instead of connected in pairs as in the ordinary method. Non-inductive resistances are connected to the transformer, motor, or other apparatus in which the power is to be measured, so as to be in series with the apparatus, and on opposite sides of it, and the four ends of these two resistances are connected with the four quadrants. Under these circumstances the deflection of the needle is a measure of the watts. To increase the maximum deflection obtainable so as to make an instrument capable of being read by a pointer, the needle is made in two halves and fixed one below the other on the same stem, and instead of quadrants, semi-circular boxes are employed. In this way a range of about 130 degrees is obtainable.

Prof. Perry enquired as to what kind of *law* the instrument had, and Mr. Blakesley asked whether it was convenient to use.

Mr. E. W. Smith pointed out that there was no necessity to take two observations in the ordinary electrometer method, for by using a false zero, one deflection gave the watts. Further the use of the

false zero rendered it unnecessary to employ any other voltmeter when experimenting at constant pressure.

The PRESIDENT said the historical part of the paper was not quite correct, and recalled attention to the fact that when high pressures were used, a single reading obtained with the ordinary method of connecting up gave the power. For ordinary low voltages, however, the false zero method described by Mr. Smith was very convenient.

Mr. SWINBURNE, in reply to Mr. Smith, said the observation of the false zero really meant another reading. As to the law of his wattmeter referred to by Prof. Perry and the President, he said he never calculated a law but calibrated the instrument directly.

Prof. S. P. THOMPSON, D. Sc., now took the chair, and a paper on "Interference with Alternating Currents," by Prof. W. E. AYRTON, F.R.S., and Dr. SUMPNER, was read by the latter. The paper relates to the phenomena which occur when alternating electric pressures are impressed on circuits made up of various combinations of resistances, condensers, arcs, and inductive coils; to the characteristics of alternators; to the properties of transformers; and to the peculiarities exhibited by the Ferranti mains. In one of the experiments an inductive coil and a condenser were connected in series and a pressure of 25 volts, as measured by a Cardew voltmeter, impressed on its terminals; the pressures on the two parts, measured in the same way, were 110 and 104 volts respectively, thus showing that each of the two parts was much greater than the whole. On joining a condenser and an inductive coil in parallel, an ammeter in the main circuit indicated 5·5 ampères whilst those in the branches showed 6·4 ampères passing through the condenser and 10 ampères through the coil. Other experiments of a similar nature were described and it was pointed out that the ratio of the sum of the two parts to the measured total may be large, being about 8 in the case first mentioned. Theoretically this ratio might be anything, depending as it does on the phases of the pressures in the two parts, and these phases are determined by the ratio of the impedance of the coil to its resistance; practically, however, it was not easy to get a coil of large self-induction and very small resistance. Alternate current arcs and condensers give results of the same general character as those above described, as also do arcs and inductive coils, such as the regulating coils of lamps; this may cause considerable error in estimating the power supplied to such lamps. The magnitude of the error was found to depend greatly on the quality of the carbons and the character of the arc. With bad carbons and a hissing arc the error was very great, but with good cored carbons burning steadily it was not very serious. Combinations of inductive and non-inductive coils exhibit marked peculiarities, particularly if the inductive one be a transformer coil. This last arrangement gave distinct evidence of interference or difference of phase when the secondary of the transformer was open, but when closed and with a moderate load, the difference of phase disappeared, thus showing that under these circumstances the primary coil had no appreciable self-induction. On the subject of alternator characteristics, a graphical method of drawing the E.M.F. curve from the terminal curve was described, and the dependence of the terminal curves on the character of the external circuit pointed out. Keeping the speed exciting current and armature current constant, the pressure between the terminals was shown to be dependent on whether the external circuit consisted of condensers, resistances, or inductive coils, the pressure being greatest in the former case and least in the latter. The true E.M.F. of the dynamo, however, was the same in all the cases, but it became less as the armature current increased. From these results the authors conclude that the drop in E.M.F. with large currents is due to reaction on the field, but that the change of terminal pressure cannot be all attributed to this cause. Transformers, it was shown, are powerful controllers of phase, for the primary and secondary currents are nearly always circulating in opposite senses; the phase angle for a 1 to 1 Mordey transformer experimented on, varying from 170° at no load to 180° at full load. The relation between the strengths of the primary and secondary currents A_p and A_s was found to be a linear one, of the form $\frac{p}{s} A_p = \alpha + \beta A_s$, where p and s are the numbers of turns in the primary and secondary respectively, and α and β constants; α representing the exciting current and β being nearly unity. The phase angle, ϕ, between the currents was given by the equation

$$-\cos\phi = \frac{\frac{1+\beta^2}{2} A_s + \alpha\beta}{\beta A_s + \alpha}$$

The results of numerous experiments on a transformer of the Mordey type, in which coils having different numbers of turns were put in parallel with each other were given. In some cases resistances were put in circuit with the coils and in others one or more of these resistances were cut out. Remarkable interference effects were thus produced, for in some combinations the volts or currents were additive, whilst in others they were nearly differential. In connection with the Ferranti effect experiments had been made by putting a condenser on the terminals of the secondary of a transformer and noting the resulting increases in pressure both in the primary and secondary circuits. The results obtained with a given condenser and approximately constant secondary pressure show:

1. That whether the transformation be up or down, the percentage rise in the secondary is greater than that in the primary.
2. That these percentage rises diminish as the secondary current increases.
3. That they increase with the ratio of transformation.
4. That the rise in the secondary may be considerable without that in the primary being appreciable.
5. That the rise in the secondary still persists, even when large currents are flowing.

These facts lead the authors to believe that the "Ferranti effect" is due to some kind of inter-action between the cable condenser and the self induction of the transformer, and that is not wholly due to armature reactions in the dynamo.

In the discussion on the paper Mr. SWINBURNE said the character of the "Ferranti effect" had been wrongly stated, for he understood Professor Ayrton to say that the pressure between the Ferranti mains was greater at the London end than at Deptford. This, he contended, was impossible. He also said the effects now described of putting a condenser on the secondary of a transformer, and noticing the rise in both primary and secondary volts, were due to the waste field of the transformer. In large transformers, such as those at Deptford, the magnetic leakage was proportionately much less, and no such effects would be noticeable with them. Referring to the relation between the primary and secondary currents in transformers, he said it was convenient to look at the primary from two points of view, and consider one part of it as producing the magnetisation, and the other as neutralising the effect of the secondary current.

Mr. MORDEY described an experiment on armature reactions in alternators, in which one of the armature coils of a 50 H.P. machine was isolated from the rest, and connected directly to a Cardew voltmeter. On varying the load from 0 to the full output (20 ampères), the voltmeter on the isolated coil was quite stationary, thus showing that no appreciable armature reaction occurred.

Mr. E. W. SMITH remarked that the formula connecting the primary and secondary currents holds true over a very wide range, for he had experimented on a Kapp transformer, which gave (α) constant and (β) = 1 for frequencies varying from 20 to 200.

Mr. BLAKESLEY gave the following formula as applying to transformer currents generally,

$$\left(\frac{A_p}{A_s}\right)^2 = \frac{n^2}{m^2}\left\{(1 + k r_2^2) + \frac{q r^2}{v}\right\}$$

where r_2 = resistance of secondary; v is proportional to the frequency; m and n the primary and secondary turns; and k and q are constants depending on the disposition of the iron. This formula he found to very nearly represent Ferrari's results, and he hoped others would test its applicability to various types of transformers. He believed himself to be the first who carried out an interference experiment, when he put a condenser in parallel with an inductive coil, six years ago. He mentioned the matter now because that arrangement had been put forward by Mr. Glazebrook, in explanation of the "Ferranti effect." Mr. Glazebrook, however, had made an error in stating that under certain conditions one of the currents may become infinite.

Dr. THOMPSON thought the word "interference" had been used in a somewhat different sense to its ordinary usage in optics, and asked for an authoritative definition of its meaning in the paper under discussion. The experiments on the alternating arc, he considered, very remarkable, as well as those on the dynamo, which give various terminal pressures when its E.M.F. and current were the same, but the external circuit of different character.

Professor AYRTON pointed out that the measurements on the rise of volts by putting on condensers, mentioned in this paper, were not strictly analogous to those made by Mr. Ferranti, for his were made by pilot transformers, one placed between the primary terminals of the Deptford transformer, and the other on the secondary of the London transformer, whereas in the cases now brought forward the volts measured were those at the primary and secondary of the same transformer. On the subject of arc lamps, he said that Messrs. Kolkhorst, Thornton, and Weekes, who made the experiments, found that great lag only occurred when the carbons were bad and the arc hissing. If the apparent and the true power spent in such an arc were measured, a great difference existed between them. Dr. Hopkinson, he said, had shown that this might be expected if the arc had a constant back E.M.F. which changed sign with the direction of the current.

A paper on "The Theory of Dissociation into Ions, and its Consequences," by Professor S. U. Pickering, F.R.S., and another on "Some Points in Electrolysis," by Mr. J. Swinburne, were postponed.

Addendum to Report of Physical Society Meeting on February 27th, 1891.

The transformer on which the tests described in Professor Ayrton and Mr. Taylor's paper were made, was of the Mordey type, having been kindly lent by the Brush Electrical Engineering Corporation.

March 20th, 1891.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

Prof. S. U. PICKERING, F.R.S., read a paper on "The Theory of Dissociation into Ions and its consequences." According to this theory, electrolytes are entirely dissociated into their ions in weak solutions. This dissociation was held by Arrhenius to absorb heat, and although heat is evolved by the dissolution of hydrochloric acid, &c., it is not maintained that dissolution evolves heat, but that the heat absorbed by the decomposition of the molecule into its atoms is more than counterbalanced by the heat supposed to be evolved by the combination of the atoms with their electric charges. These actions the author considers improbable, and thought that before being accepted, the theory must give satisfactory answers to the following questions:—How can matter combine with an affection of matter to produce heat? Whence do the electric charges originate? Why does not the opposite electrification of the different atoms make them cling more firmly together instead of dissolving the union between them? and why should an atom which possesses a strong attraction for a negative charge (such as chlorine) go to the positive electrode during electrolysis?

When a dilute solution, which is supposed to contain some gaseous molecules, is further diluted, then, according to the theory, some of the molecules are dissociated, and, if heat is absorbed, it follows that the dissociation, and therefore dissolution, of the gas must absorb

heat, yet, he said, it can be shown that in some of these cases the dissolution of a gas evolves a large amount of heat.

The antagonism between the present, and the old electro-chemical theory, according to which the atomic charges are identical with the free energy of an atom and are the cause of combination, not decomposition, was commented on, as well as the disagreement between the present theory and Clausius's view that there are are a few ions or atoms present in a liquid owing to accidental superheating of some of the molecules. Reasons, however, were adduced for believing that the presence of even a few atoms in a solution to be improbable.

A communication on "Some points in Electrolysis" was made by Mr. J. Swinburne. Considering a reversible single fluid cell, the author, by a process of reasoning based on Carnot's principle and the conservation of energy, arrives at Helmholtz's equation, $E = E_c + \theta \frac{d E}{d \theta}$ where E is the electromotive force, E_c the part due to chemical action, and θ the absolute temperature. Writing the equation in full, using suffixes n and p to denote the negative and positive plates, it becomes

$$E_n + E_p = E_{nc} + E_{pc} + \theta \frac{d E_n}{d \theta} + \theta \frac{d E_p}{d \theta}.$$

He then shows that by having the two plates in different vessels and heating them to different temperatures, the Peltier effects represented by $\theta \frac{d E_n}{d \theta}$ and $\theta \frac{d E_p}{d \theta}$, can be determined separately. Similarly those of a two fluid battery might be found by arranging the junction of the fluids in a third vessel.

After pointing out the desirability that the conditions under which all thermo-chemical data has been obtained should be clearly stated, he proceeded to show that any cell in which secondary actions occur (as, for example, if zinc oxide primarily formed by electrolysis were to dissolve in sulphuric acid), must necessarily be non-reversible. He also contended that in a secondary battery, the formation of lead sulphate on both plates is the essence of the cells' action, and that there is no intermediate formation of PbO.

On the subject of so-called "nascent" hydrogen or oxygen, he said that reasoning from the conservation of energy showed that neither could exist. Taking the case of persulphate of iron in dilute sulphuric acid, which is said to be reduced to protosulphate by the "nascent hydrogen" liberated on putting a piece of metal (say magnesium) into the liquid, he said a better explanation of the phenomena would be, that the metal dissolves, if it either reduces the metal, or evolves hydrogen; and as the former requires less energy, the reduction takes place, and when no reducible salt is available, hydrogen is evolved. Evolution of hydrogen, and reduction of the per salt, are thus *alternative* and *not consecutive actions*.

Examining Dr. Lodge's views on the contact E.M.F. between metals, he remarked that if the tendency of a metal (such as zinc) to oxidise can produce an electric stress or difference of potential which prevents further combination, actual combination must charge the metals if it be insulated. A piece of sodium, however, oxidises continuously and therefore should become charged to an enormous potential. As this effect is not known to occur, the author suggested that the Volta effect may be due to films of water, and in support of this view adduced the fact that metals when perfectly dry do not combine with chlorine, and that even sodium is not attacked by dry chlorine.

In the discussion on the two papers, Prof. Pickering said the idea of nascent elements had, to a large extent, been given up by chemists, and pointed out that the fact of one reaction taking place rather than another, was not merely a question of heat energy, but that a kind of chemical selection was involved.

Prof. S. P. Thompson recalled attention to the fact that the products of electrolysis depend on the E.M.F. employed in producing it, and thought the E.M.F required to produce the various products might be taken as a measure of their affinities. He did not agree with Mr. Swinburne's method of finding the E.M.F. of a secondary battery from thermochemical data, for he failed to see how two similar actions going on at the two plates of a cell could add anything whatever to the E.M.F. of the cell.

The President said the question whether the potential difference between two dissimilar substances was due to oxidation or to mere contact, could only be decided by direct experiments made in a vacuum from which all traces of moisture and oxygen had been removed. Without agreeing with Dr. Lodge's view on the subject, he pointed out that the continuous oxidation of a piece of insulated sodium need not necessarily produce a great potential difference, for the combination might produce heat.

After Prof. Pickering and Mr. Swinburne had replied to the points raised, Mr. Walter Bailey took the chair, and Prof. Perry read a note "On the Variation of Surface-Tension with Temperature," by Prof. A. L. Selby, M.A. Considering unit mass of liquid at constant volume, but variable surface (S), and temperature (t), the author expresses the gain of intrinsic energy due to changes of the variable by $d H + d W = k\,dt + (l + T)\,d S$, where $d H$ is the heat absorbed, $d W$ the work done on the film, k the specific heat at constant volume, l the latent heat of extension, and T the surface-tension. This being a perfect differential, it is shown that $T = c - b t$, and $l = b t$, c and b being constants.

Supposing c and b to be independent of the specific volume of the liquid, it is shown that at the critical temperature $t = \frac{c}{b}$, hence this temperature may be determined by finding the surface tension at two very different temperatures. Since also $l = b t$, the latent heat of extension is proportional to the absolute temperature. Reasons for supposing b to be independent of the specific volume are given n the paper.

Mr. Blakesley described an effect of temperature on surface tension which he had observed in sensitive spirit levels. By warming one end of the tube, even by the hand, the bubble immediately moves towards that end. This effect, which might produce considerable error in engineering operations, was, so far as he was aware, not mentioned in the text books.

Prof. Perry remarked that although the volume, temperature and surface of the liquid had been referred to in the paper, pressure was not mentioned, and on this point he enquired whether the results arrived at were true, quite independent of the pressure.

Prof. S. P. Thompson, D.Sc., read a paper on "Magnetic Proof Pieces and Proof Planes." The distribution of magnetism over magnets has been examined in various ways by different observers, but mostly by observing the force of detachment of either rods, ellipsoids or spheres, &c., used as proof pieces. In all these cases it was, the author said, difficult to see exactly what was measured, for the presence of the proof pieces altered the thing to be tested. The pull exerted must also depend on the permeability of the piece used, as well as on its shape and disposition with respect to the magnetic circuit. He had therefore investigated the subject by finding the actual distributions by means of a flat exploring coil and ballistic galvanometer, both with and without the presence of proof pieces of various shapes and sizes. The results show that the perturbations produced by the proof pieces are always large, in some cases the perturbed field about a point being four to six times the unperturbed field. In most cases, however, the ratio of the perturbed to the unperturbed field was constant so long as the former did not exceed 6,000 C.G.S. units.

The amount of perturbation was also found to depend on the saturation of the magnet and on whether it was a permanent or an electro-magnet. The numbers obtained in various experiments, and curves plotted from such results, were shown.

In conclusion, the author said that in using proof pieces much depended on the accuracy of the contact, but, in any case, the results obtained were not very reliable. The flat exploring coil, or magnetic proof plane, however, furnished a satisfactory method of examining magnetic distributions.

NEW PATENTS—1891.

1,051A. "Improvements in testing electrical transformers and dynamos during the manufacture of the same." S. Z. de Ferranti. Dated March 12th. (This application having been originally included in No. 1,051, dated 20th January, 1891, takes, under Patents Rule 23, that date.)

4,170. "An improved method for the distribution of electricity." W. H. Willatt. Dated March 9th.

4,188. "Improvements in electrolysis." J. A. Mays. Dated March 9th.

4,214. "Improvements in telephones." J. F. Bennett and E. P. Hides. Dated March 10th.

4,215. "Automatic electrical block-signalling on railways, with mechanical arrangement for testing the same." A. D. Macdonald and J. Dodd. Dated March 10th.

4,235. "Improvements in transmitter for electric step-by-step telegraphs." G. E. Fletcher. Dated March 10th.

4,256. "Improvements in insulation of electric conductors." F. J. Nash. Dated March 10th.

4,259. "Improvements in electric motors." H. H. Lake. (Communicated by The Giant Electric Motor Company, United States.) Dated March 10th. (*Complete.*)

4,263. "Improvements in means for preventing induction in telephones." T. F. Wright and E. G. Wilson. Dated March 10th. (*Complete.*)

4,269. "Improvements in insulated electric wires." F. J. Nash. Dated March 10th.

4,271. "Improvements in electrical railway signalling." P. A. Newton. (Communicated by The American Electric Railway Signal Company, United States.) Dated March 10th. (*Complete.*)

4,306. "Improved methods of and apparatus for obtaining electricity and in connection therewith." W. Boggett. Dated March 10th.

4,367. "An improved electric signal and search-light lantern." W. H. Munns. (Communicated by G. W. Martin and J. Knight, United States.) Dated March 11th.

4,374. "An electrical singeing apparatus for textile fabrics." L. Lettre. Dated March 11th. (*Complete.*)

4,392. "Improvements in electrical bell and electrical alarm clock apparatus, applicable for use either in combination or separately." W. Entwisle. Dated March 11th.

4,407. "Improvements in the electric connection of lightships with the mainland." F. Linke. Dated March 11th.

4,410. "An improved telephone enunciator or indicator." W. W. Horn. (Communicated by G. R. Lawrence and C. H. Oakwood, United States.) Dated March 11th.

4,468 "An improvement in casings for electrical switches, safety fuses, ceiling roses, and similar fittings." C. D. Abel. (Communicated by H. Messing, Germany.) Dated March 12th.

4,469. "An improvement in resistances employed for electrical measurements." J. CLEGG. Dated March 12th.

4,471. "Improvements in electrical switch boards and fuse boards." W. WHITE. Dated March 12th.

4,479. "Improved means for insulating underground electrical conductors." L. F. H. C. MORGAN-GRENVILLE. Dated March 12th.

4,482. "Improvements in and relating to telephonic switch boards." C. J. PRICKETT. Dated March 12th.

4,551. "An improved tablet or pad for use in connection with telephones." H. KING. Dated March 13th.

4,554. "Improvements in armatures for electrical machinery." G. F. REDFERN. (Communicated by Wirth & Co., agents for W. Lahmeyer & Co., Germany.) Dated March 13th.

4,579. "Improvements in switches for electric cigar lighters and like purposes." G. BINSWANGER and C. H. SMEETON. Dated March 14th.

4,583. "Improvements in electric supply meters." J. PERRY. Dated March 14th.

4,588. "An improved counterweight arrangement for electric lamps." J. M. M. MUNRO. Dated March 14th.

4,605. "Improvements in electric lighting and for other like purposes." R. J. RAE. Dated March 14th.

4,641. "Electro-magnetic counter and time indicator for indicating the movements of moving bodies." J. GORIUP. Dated March 16th.

4,643. "Improvements in and connected with chains, cables, and couplings for electrical mains and other purposes, or for insulating, protecting, carrying, or conveying electrical mains and other elements, and in preliminary preparation or insulation of such mains for being so carried, conveyed, and protected." P. H. WILLIAMS. Dated March 16th.

4,669. "Apparatus on the principle of utilising heat as a source of electricity." V. HIRBEC. Dated March 16th.

4,678. "Improvements in terminals for electrical purposes." J. PILKIN. Dated March 16th.

4,682. "Improved means for securing safety in electrical supply systems." S. Z. DE FERRANTI. Dated March 16th.

4,684. "Improvements in instruments for measuring and adjusting magnetic force." W. MAYES. Dated March 16th.

4,689. "Electric switches." C. E. CHALLIS. Dated March 16th.

4,715. "Improvement in a process of and apparatus for electrically reproducing uneven, irregular, or undulating surfaces." N. S. AMSTUTZ. Dated March 17th. (*Complete.*)

4,740. "Improvements in and connected with electric signalling for railways." G. F. ATTREE. Dated March 17th.

4,751. "Improvements in electrical transportation systems." O. IMRAY. (Communicated by S. S. Wheeler and C. S. Bradley, United States.) Dated March 17th. (*Complete.*)

4,757. "Improvements in the electric reduction of aluminium and other metals and in the production of alloys thereof." T. L. WILLSON. Dated March 17th.

4,758. "Improvements in electric railways." A. M. CLARK. (Communicated by The Waddell-Entz Electric Company, United States.) Dated March 17th. (*Complete.*)

4,781. "A new or improved solution or electrolytic fluid for galvanic batteries." W. J. ENGLEDUE. Dated March 17th.

4,792. "Electric type writers." E. J. SILEMAN. Dated March 17th. (*Complete.*)

4,794. "Improvements in signalling and telephonic systems." J. E. KINGSBURY. (Communicated by The Western Electric Company, United States.) Dated March 17th.

4,812. "Improvements in the construction of incandescent lamps." H. A. MILLAR. Dated March 18th.

4,831. "Improvements in holders for incandescent lamps." W. MCGEOCH, Jun., and A. J. MCGEOCH. Dated March 18th.

4,838. "Improvements in incandescent electric lamps." M. BAILEY and J. WARNER. Dated March 18th.

4,860. "Improvements in apparatus for heating and welding by the electric arc. H. HOWARD. Dated March 18th.

4,869. "Improvements relating to primary and secondary electric batteries, and to the manufacture of plates or electrodes for use therein." H. H. LAKE. (Communicated by L. A. W. Desruelles, France.) Dated March 18th.

4,881. "Improvements in electric tramways or railways." A. M. CLARK. (Communicated by S. Schuckert and Co., through Wirth and Co., Germany.) Dated March 18th.

4,882. "Improvements in electric indicators." F. J. DUCK. Dated March 18th.

4,949. "Improvements in galvanic batteries." J. Y. JOHNSON. (Communicated by A. Tardy, France.) Dated March 19th.

5,003. "Improvements in holders or supports for incandescence electric lamps." J. Y. JOHNSON. (Communicated by T. Mace, Holland.) Dated March 20th.

5,021. "Improvements in electric accumulators." H. H. LAKE. (Communicated by G. Gandini, Italy.) Dated March 20th. (*Complete.*)

5,043. "An improved apparatus for regulating the approach of the carbons in arc lamps." A. W. MONEY and H. NASH. Dated March 20th.

CORRESPONDENCE.

Electro-motors.

Fifteen or sixteen years ago, when I was pursuing my course at the college, I was told by an eminent physicist that a motor could not be operated without the use of brushes and commutators, or mechanical means of some kind for commutating the current. It was then I determined to solve the problem.

After years of persistent thought I finally arrived at a solution. I worked out the theory to the last detail, and confirmed all of my theoretical conclusions by experiments. Recognising the value of the invention, I applied myself to the work of perfecting it, and after long continued labour I produced several types of practical motors.

Now all this I did long before anything whatever transpired in the whole scientific literature—as far as it could be ascertained—which would have even pointed at the possibility of obtaining such a result, but quite contrary at a time when scientific and practical men alike considered this result unattainable. In all civilised countries patents have been obtained almost without a single reference to anything which would have in the least degree rendered questionable the novelty of the invention. The first published essay—an account of some laboratory experiments by Prof. Ferraris—was published in Italy six or seven months after the date of filing of my applications for the foundation patents. The date of filing of my patents is thus the first public record of the invention. Yet in your issue of March 6th I read the passage: "For several years past, from the days of Prof. Ferraris's investigations, which were followed by those of Tesla, Zipernowsky and a host of imitators," &c.

No one can say that I have not been free in acknowledging the merit of Prof. Ferraris, and I hope that my statement of facts will not be misinterpreted. Even if Prof. Ferraris's essay would have anticipated the date of filing of my application, yet, in the opinion of all fair-minded men, I would have been entitled to the credit of having been the first to produce a practical motor; for Prof. Ferraris himself denies in his essay the value of the invention for the transmission of power, and only points out the possibility of using a properly-constructed generator, which is the only way of obtaining the required difference of phase without losses; for even with condensers—by means of which it is possible to obtain a quarter phase—there are considerable losses, the cost of the condensers not considered.

Thus, in the most essential features of the system—the generators with the two or three circuits of differing phase, the three-wire system, the closed coil armature, the motors with direct current in the field, &c.—I would stand alone, even had Prof. Ferraris's essay been published many years ago.

As regards the most practicable form of two-wire motor, namely, one with a single energising circuit and induced circuits, of which there are now thousands in use, I likewise stand alone.

Most of these facts, if not all, are perfectly well known in England; yet, according to some papers, one of the leading English electricians does not hesitate to say that I have worked in the direction indicated by Prof. Ferraris, and in your issue above referred to it seems I am called an imitator.

Now, I ask you where is that world-known English fairness? I am a pioneer, and I am called an imitator. I am not an imitator. I produce original work or none at all.

Nikola Tesla.

New York, *March 17th*, 1891.

Electrically Charged Spheres.

The following simple proof of the law that the electric force exerted between two small charged spheres varies *inversely* as the specific inductive capacity of the medium in which they are immersed, may be of value to elementary students of electricity.

1. Suppose that we have an air-condenser formed of two concentric spherical shells. Let v and v_1 be respectively the

potentials of the inner and outer coatings; and r and R their respective radii. Then by a well known equation;—

$$V - V_1 = Q\left(\frac{1}{r} - \frac{1}{R}\right)$$

where Q = the charge. Dividing each term by Q, we get

$$\frac{1}{C} = \left(\frac{1}{r} - \frac{1}{R}\right)$$

where C = the capacity of the condenser. If we now replace the air by a dielectric of specific inductive capacity, σ, this equation becomes by definition—

$$\frac{1}{C} = \frac{1}{\sigma}\left(\frac{1}{r} - \frac{1}{R}\right)$$

Let the outer sphere be now enlarged infinitely, which is of course equivalent to placing the *inner* sphere at an infinite distance from any other body, then $\frac{1}{R}$ in the above equation becomes $\frac{1}{\infty} = 0$, thus

$$\frac{1}{C} = \frac{1}{\sigma} \times \frac{1}{r}$$

or,

$$C = \sigma r$$

where C = the capacity of a sphere of radius r.

2. Now the potential, V_2, just outside this sphere,

$$= \frac{Q}{C} = \frac{Q}{\sigma r}$$

Let V_3 = the potential due to this sphere at a distance d. Then since the potential varies inversely as the distance (or potential × distance = a constant) it follows that:—

$$V_3 d = V_2 r$$

$$= \frac{Q}{\sigma}$$

since $V_2 = \frac{Q}{\sigma r}$

Hence

$$V_3 = \frac{Q}{\sigma d}$$

But the electric force $F = \frac{V_3}{d} = \frac{Q}{\sigma d^2}$

Therefore

$$F \propto \frac{1}{\sigma}$$

It should be remarked that this law only holds when the distribution of electricity on one body is not affected by the charge of the other. It can easily be shown, for instance, that in the case of the attracted disc electrometer, the force exerted between the plates varies inversely as the *square* of the specific inductive capacity of the intervening dielectric.

Frederic J. Cheshire.

March 23rd, 1891.

Copper Steam Pipes.

It was with great pleasure and profit I read your very intelligent leading article on the above subject; in fact, it is more to the point, *pro* and *con*, than all the leading articles of the engineering journals, correspondence, and official enquiry reports we have had on the subject. Your article very ably clears all unnecessary prejudice and uneasiness by showing the defects in their true light. In the case of the *Elbe* we have a positive proof of defective workmanship, both in the coppersmiths' and engineers' departments. The coppersmith did the job piecework, and no practical man to superintend him, and the engineers had a bad pipe arrangement allowing the water to accumulate, so as to act as a ram with nothing to give, and if the pipe had not burst the cylinder bottom very likely would have gone. Had there been anything like fair play done to the trade, we should not have these cases being continually trotted out as evidence against us. It is fashionable in our trade (when now, more than at any other time, practical experience is essential), to have for round holes *square men*; that is, our trade is becoming a happy hunting ground for every tinker that has presumption enough to apply to a manager and presume to do the work cheaper than has been done. This is a fact. I could name three or four large engineering firms that are doing so. On the *Elbe's* job a brass finisher was foreman over coppersmiths, plumbers, moulders, and brass finishers; any man in his senses would never imagine he was qualified to look after the different work properly, let alone having the men on piecework. Owing to competition, we are told, expenses have to be put down to the lowest. With the Deptford job, why was the work taken to Manchester, where such work is not a speciality? The job stands condemned, for if the pipe was estimated as being $\frac{1}{4}$-inch thick, how comes it to be less than $\frac{1}{8}$-inch thick in any part? The seam part should be the thickest.

The *Jumna's* pipe also shows a want of proper supervision; a defect is here shown that will condemn the Ferranti pipe, of which your contemporary, the *Engineer*, makes so much ado. In main steam pipes there are often sharp bends, and with solid drawn tube it has to be bent, so reducing the thickness of the back, which is the only cause I can give of the *Jumna's* pipe giving out. In a worked pipe properly put together, the seam is the thickest and strongest part of it; also there is a uniform thickness throughout. The Ferranti pipe might answer for a stationary engine, but for a marine engine would be unpractical, owing to the working of the ship and the vibration, and would lead to endless trouble. Mr. Ferranti has evidently got his idea from the German or Swedish engineers, who use iron flanges with a groove in to allow for a collar to be turned off the copper pipe. The idea is as old as Adam's clogs, and so practical, that the American line of boats (Richardson, Spence & Co.) had all their pipes flanged in that way in New York, but found them thoroughly unfit for the work, and had them altered in Liverpool to the English style. A similar arrangement was tried at the Wallsend Slipway and Engineering Company's works, two iron flanges with a bead for the collar of the copper pipe to bear on. This stood the test, but for working purposes was found wanting, so the old style was re-adopted. I maintain if engineers will insist on having competent men to do the copper pipes, there will be nothing to fear; but only where men are allowed to interfere with work they have no knowledge or experience of. I know of cases where a fitter took to repairing a main steam pipe, and botched it; that was in Southampton. Another case, an ironmonger took a job in hand, a main steam pipe to repair (this was in Plymouth); he did not keep coppersmiths, so he got the plumbers to do it, which they did after a style; they spoilt the pipe, and had to get permission of "H.M." dockyard officials to allow the job to be done by competent men in the dockyard; so it behoves those in authority to know and see who does the work, and so prevent these calamities from taking place. If, in passing for an engineer, a man has to produce evidence to show his practical ability, it is reasonable that some care should be taken in a trade where so much depends on it. Hoping in these times to awaken an interest in a trade that's been anything but fairly dealt with, allow me to return you my best thanks for your able championship of it.

William Dooley.

March 30th, 1891.

Magnetic Attraction.

The subjoined may be of interest, now that the law of magnetic attraction is occupying such attention.

The following occurs in a book published in 1734, viz.:—"Desagulier's Experimental Philosophy." "Dr. Petrus van Muschenbroek, the ingenious professor of astonomy, &c., at Utrecht, has, with indefatigable pains and application, made experiments of the attractions and repulsions of loadstones in respect to iron and to each other, but could never find any regular proportion in the increase of attraction in their approach to, or decrease of attraction in their recess from, one another, only that the force of magnetick virtue did increase in the approach to, and diminish in the recess from, the stone; but not exactly as the distance, nor as the square, or cube of the distance, nor as the square or cube of the distance reciprocally, nor in any proportion reducible to numbers."

Ralph Conrad Richards.

Our Isolated Lighthouses.

The columns of the *Standard* of March 28th contain, under the above title, a lengthy contribution from the pen of a Mr. J. G. Wren, advocating the connecting of our coastguard stations with one another by telephone or telegraph, and the establishment of telegraphic communications between the mainland and the lightships and detached lighthouses round our coasts by means of submarine cables.

With regard to the coastguard stations, there cannot be two opinions as to the expediency of linking them together and connecting them with lifeboat stations and with the main system of postal telegraphs. A scheme of this nature has been advocated for some considerable time, and its execution has been repeatedly urged not only in the columns of technical journals but also in the pages of the daily press. The carrying out of the project presents no difficulty beyond the incurring of a considerable outlay on material.

As to the utility of these communications, I would not attach so great a measure of importance to their possible service, where naval manœuvres or an invasion are in question, as Mr. Wren would appear to, since there is a more immediate and far more urgent duty awaiting them. There is only too ample evidence to show their absolute value in the case of wrecks occurring at some distance from a lifeboat station when word of the disaster must, without their mediation, be conveyed by messenger, and when every minute gained or lost in the appeal for help is fraught with so much significance.

Mr. Wren does well in calling public attention to the indifference of the authorities in the matter of these particular communications, which, whether looked upon from the view of Imperial defence, or regarded as a means of assisting towards the preservation of life, possess an importance which far outweighs any consideration of cost.

But when we come to the question of connecting detached lighthouses with the mainland, I am compelled to express the conviction that Mr. Wren has scarcely given the subject sufficient consideration. I do not for a moment contend that the project is other than one to be most heartily approved of, or that its realisation is impossible, but I hold that the difficulties are very great, and I can readily understand that these difficulties cannot be appreciated by one who assumes that "there is no more difficulty in running a cable from the Land's End to the Wolf, or from Rame Head to the Eddystone, than there is between any two points with a firm base." Although Mr. Wren may have had no opportunity of acquainting himself with the vicissitudes to which a cable, laid under the required conditions, is exposed, yet he might have been able to form some idea of the terrific seas which sweep and eddy round outlying rocks in exposed positions. I would recommend to Mr. Wren a study of the experience acquired by one of our leading submarine cable manufacturing companies, who after continued attempts to maintain a communication of the nature under discussion, were eventually compelled to abandon the enterprise.

Mr. Wren dismisses the question of cost as quite unworthy of consideration, in view of the benefits to navigators which may possibly be derived from the laying of telegraph cables to these isolated rocks. The real difficulty does not lie in the monetary outlay, but in the fact that the cable is likely to fail at the very time, that is to say in bad weather, when it might be of some service. If, however, the idea of a perfectly unlimited expenditure is to be entertained, I would humbly suggest that it might perhaps prove a more permanent advantage were the rocks removed.

Still more salient are the difficulties opposed to the connecting up of lightships, and although the authorities at certain of our principal ports have earnestly considered the question, and have collected suggestions and proposals from many quarters, no satisfactory solution of the problem seems to have been arrived at. The obstacles which have presented themselves to engineers who have studied the matter, do not seem to trouble Mr. Wren, and anyone unacquainted with the merits of the case would, no doubt, wonder why such simple methods as proposed by that gentleman have not been put into execution. The reason for hesitation does not lie, I think, in a want of enterprise, or in the question of cost, but may probably be attributed to the fact that such suggestions as have been made do not carry sufficient conviction as to their efficacy.

As to the loss of the *Schiller*, a case which Mr. Wren quotes in support of his contention, I consider he is entirely at fault in his estimate of the service a telegraph cable would have rendered in this particular instance, but this is a matter of opinion; as to Mr. Wren's friend, the nautical gentleman who "averred that as soon as the look-out man sighted Scilly from the masthead he called all hands to prayers, and gave himself up as a total wreck," I trust that few of our navigators are of this kidney; all the telegraph cables in the world would be of little service to a man who, on sighting a rock, considered that he adopted the best means of clearing it by going down on his marrow bones.

I do not wish my criticism of Mr. Wren's arguments to be misunderstood. I agree with him as to the desirability of making experiments in the connecting of lighthouses and lightships with the mainland by means of telegraph cables, and I do not share the opinion, so frequently expressed, that the advantage of these communications is more fanciful than real. But I do not think that the matter is to be advanced by ill-directed advocacy, nor is success to be finally achieved by thoughtless precipitancy. Nothing can be gained by seeking to disguise the difficulties which must be overcome, and which are patent to every engineer who possesses any practical knowledge of the subject.

Some progress in the desired direction may, however, be realised by ventilating the subject in the press, even when the method of advocacy adopted leaves room for criticism. Repeated iteration may arouse public interest in the question, and once this has been effected, the authorities will be compelled to pay some attention to the reforms demanded. But before any doubtful experiments are embarked upon, let us see a commencement towards the realisation of the most necessary of the three classes of communication, that is the joining together of our coastguard and lifeboat stations.

Submarine.

The Cores of Submarine Cables.

With reference to the article in your paper of the 20th inst. on India-rubber core in submarine cables, I would like to be permitted to make a few observations bearing on the points raised.

With regard to attacks from marine cable borers, they are almost unknown in Hooper's core, though when the bare core has been exposed in shallow water it has been damaged by the attachment of shells of molluscs.

Experiments made in 1874 by submerging some pieces of each description in Kurrachee Harbour, to ascertain whether India-rubber was as liable to the attacks of borers as gutta-percha, appear to clearly prove that India-rubber core, either protected or unprotected, is very much less liable to the attacks of the teredo than gutta-percha.

This is confirmed in the report of the cables with Hooper core, laid in the West Indies, where in no instance had the core been discovered to be pierced by the teredo, which swarms in these waters, though the hemp-yarns in innumerable places had been cut into short lengths.

With reference to jointing, out of 17 gutta-percha joints and 12 India-rubber joints tested for upwards of 12 months in the sea at Manora, the insulation showed a gradual decrease in the case of the gutta-percha joints, while the India-rubber remained steady. Details of these tests will be found in No. XII., Vol. IV. of the *Journal of the Society of Telegraph Engineers*.

It is difficult to make a bad joint in Hooper's core if ordinary precautions are taken to keep the materials clean and free from moisture. It may take a longer time on account of the vulcanisation, but this makes the core homogeneous, which it is not with a gutta-percha joint.

I am glad to state that the cable laid on the South Coast of Cuba, under guarantee, in 1881, has lately been successfully repaired in deep water by Mr. George Keith.

This cable was made up of the surplus pieces of deep-sea cable manufactured for the Western and Brazilian Telegraph Company in 1873 and 1874. In repairing this cable, and another laid in 1875 (both broken), the core in the cable picked up was as sound as when laid, and no difficulty was experienced in localising the breaks.

John P. Hooper.

March 31st, 1891.